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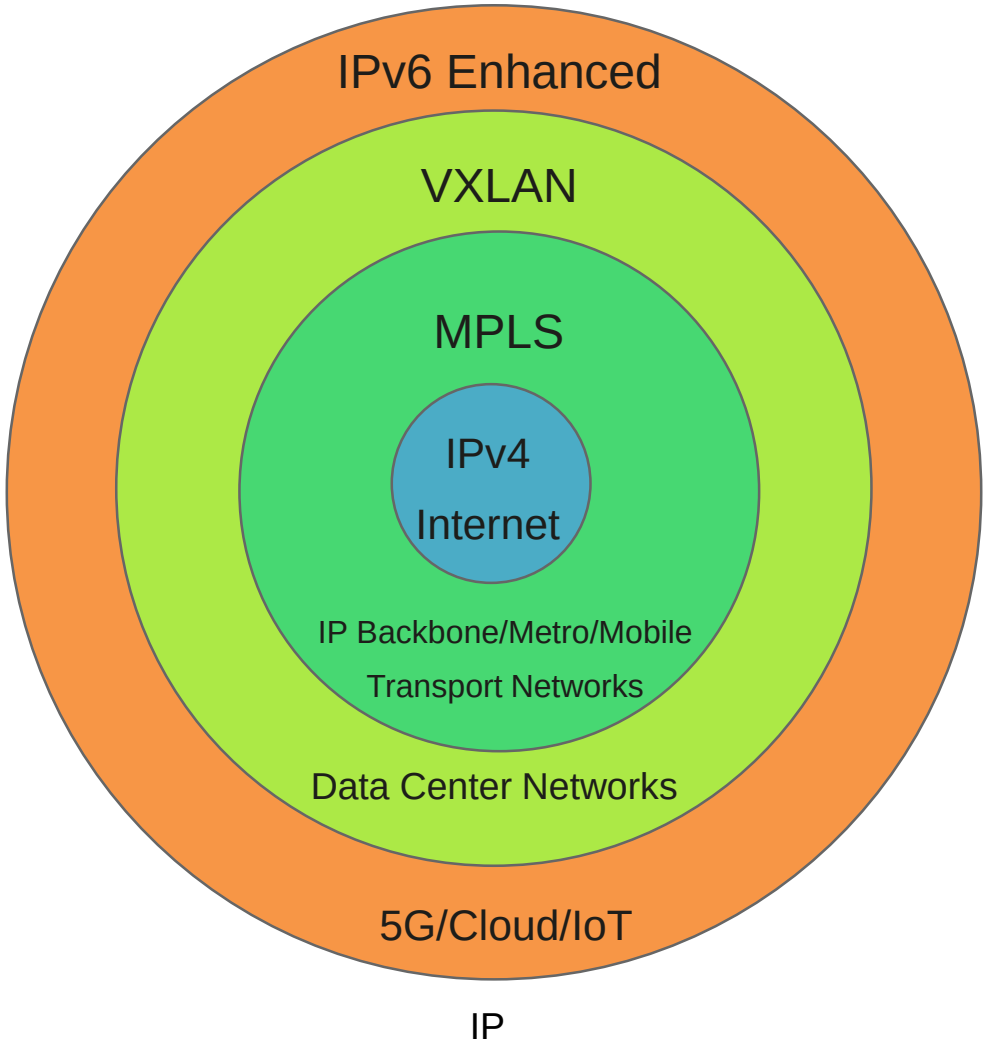
MPLS SD&AI NET WORLD 23

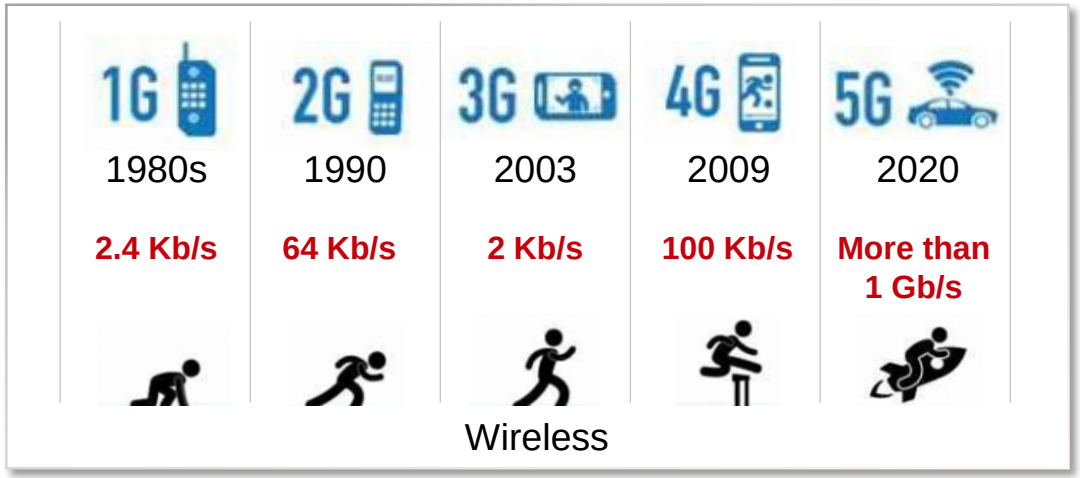
IPv6 Enhanced: A New Era of IP Networks

Zhenbin Li
Chief IP Protocol Expert, Huawei
lizhenbin@huawei.com

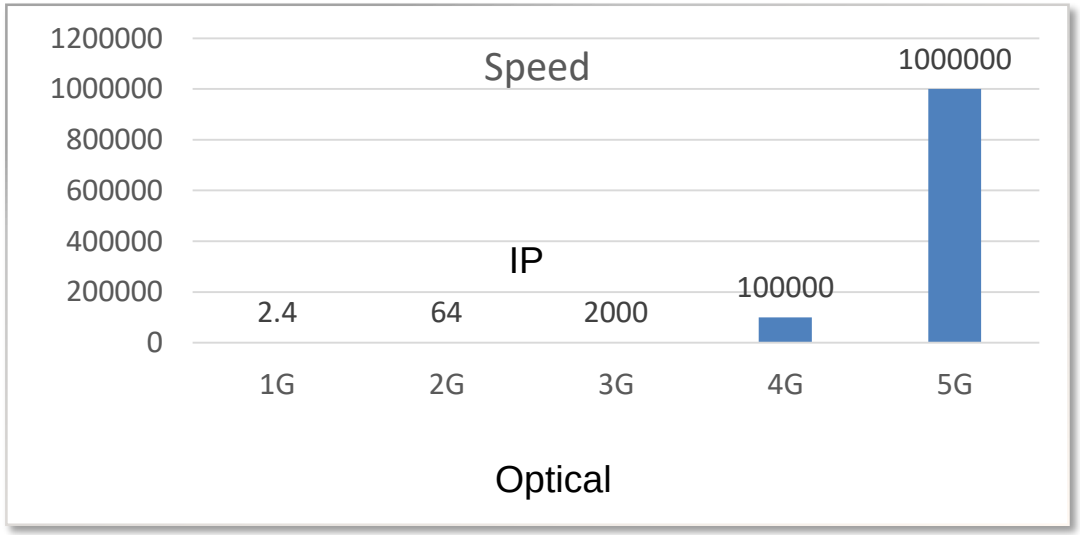
IP Evolutions: Applications Drives the Change of IP Network Architectures



IP



Wireless



Optical

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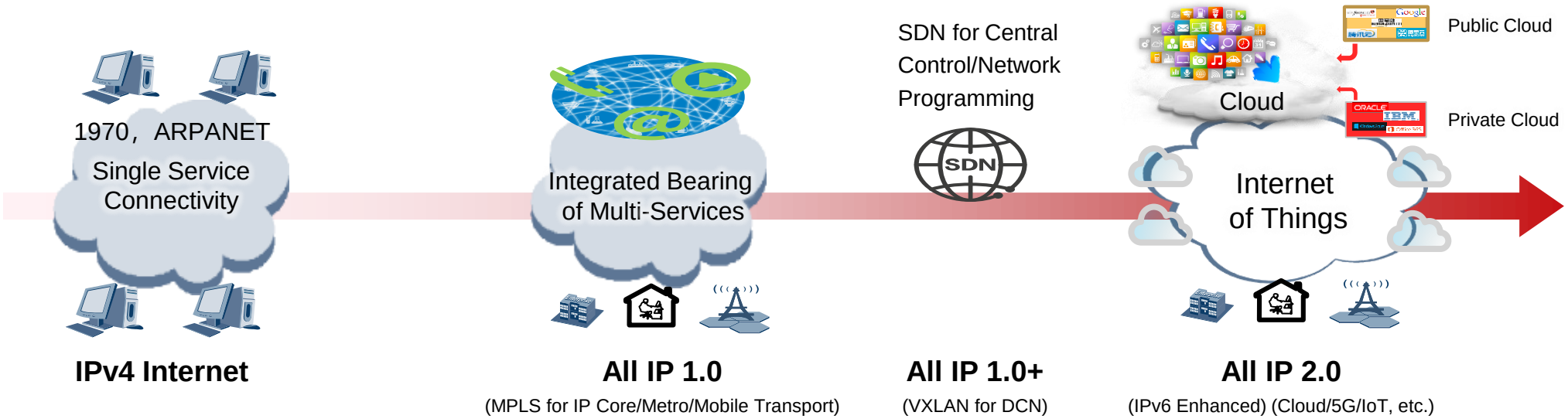
IPv6 Enhanced: A New Era of IP Networks



- Rethinking on IPv6: Address Space is not enough.
- New Chance of IPv6: 5G changes the attributes of connections, and cloud changes their scope.
- Mission of IPv6 Enhanced:
  - 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.

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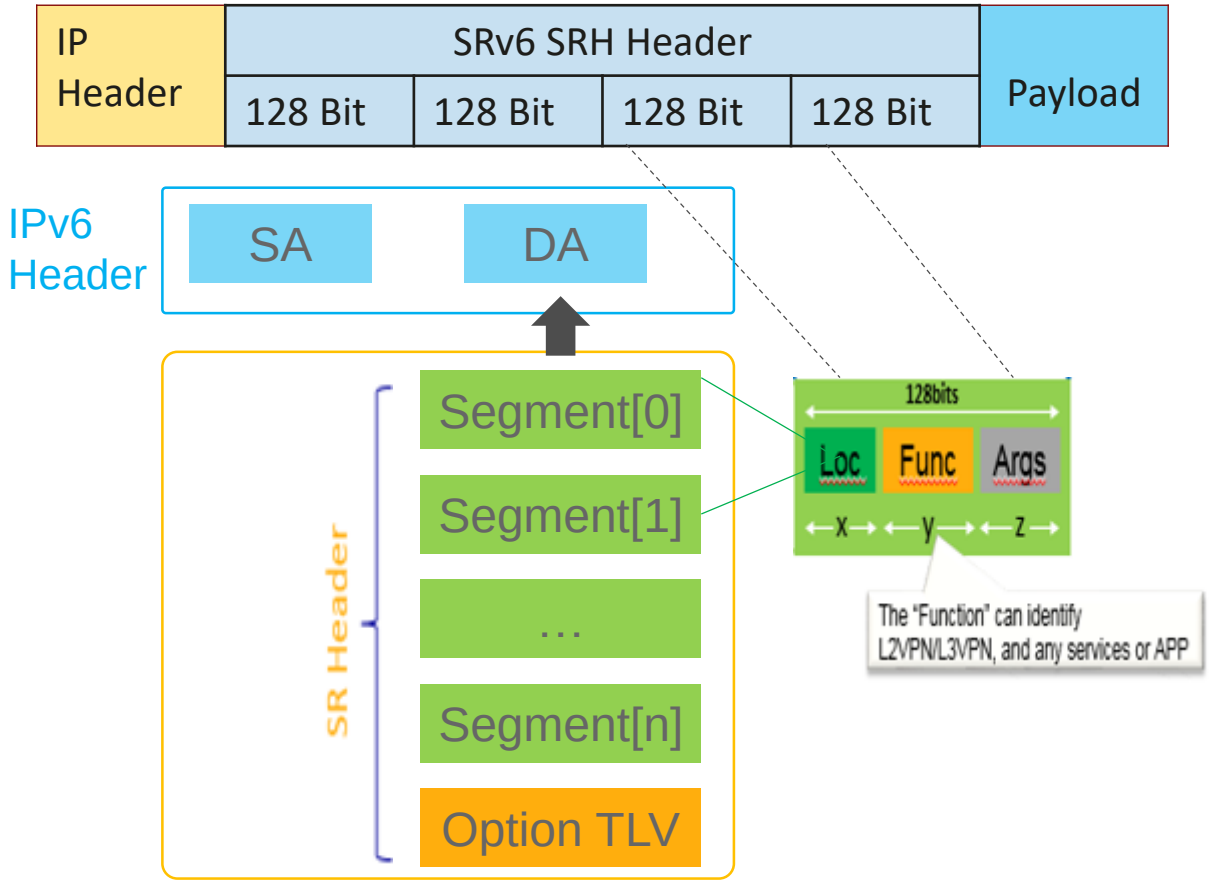
IPv6 Extension Headers and SRv6: Release Network Programming Capabilities

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			

30 years ago, because of limitation of network hardware capabilities, the hardware-friendly design (MPLS: fixed-length packet header) was adopted to extended network functionalities (VPN/TE/FRR, etc.)

SRH: Three Layers of Programming Spaces



In the new era, breakthrough of network hardware and programming chipset capabilities makes IPv6 extensions (variable-length packet header) possible to support more network services.

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IPv6 Enhanced Research and Standard Planning: SRv6 is only a starting point

IPv6 Enhanced 1.0: SRv6 Basic Capabilities

- SRv6 VPN
- SRv6 TE
- SRv6 FRR

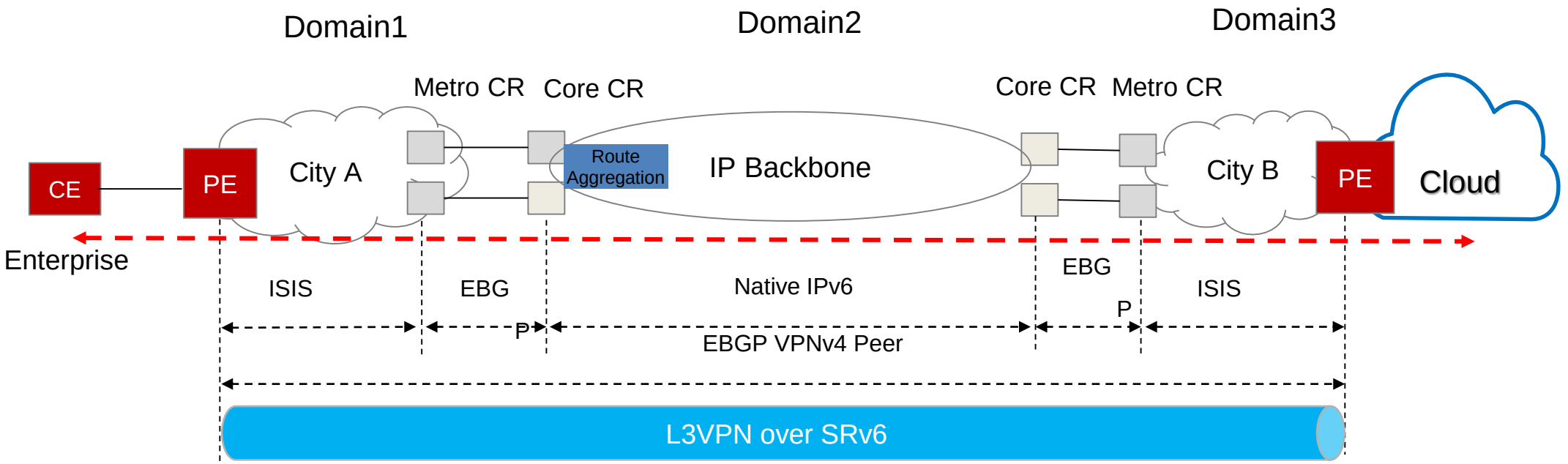
IPv6 Enhanced 2.0: New Network Services for 5G/Cloud

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

IPv6 Enhanced 3.0：APN6 – App-aware network architecture

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

SRv6 Evolution: End-to-end Network Unified Forwarding Process



- **Simplicity and Scalability**: Work based on IPv6 reachability, no extra signaling. More scalable benefiting form route aggregation.
- **Convergence**: 10+ Protocols are converged to SRv6 + EVPN to simplify the service provisioning.
- **E2E and incremental deployment**: Unified process to converge different IP network domain. TE and SFC can be deployed incrementally and easily.
- **Extensibility**: Possibility to be extended to support more new services based on IPv6 as the starting point.

SRv6: Mature Standardization and Rich Eco-system

Mature Standardization

5 RFCs are released

- RFC 8986 SRv6 Network Programming
- RFC 8754 IPv6 Segment Routing Header
- RFC 9252 SRv6 VPN
- RFC 9256 SR Policy Architecture
- RFC 9259 OAM in SRv6

40+ Drafts are becoming Standard RFC

Mainstream Vendors already support SRv6

HUAWEI, CISCO, JUNIPER NETWORKS, NOKIA, BAREFOOT NETWORKS, BROADCOM, MARVELL, ZTE, SPIRENT Communications, ixia, ARRCUS NETWORK DIFFERENT, …more

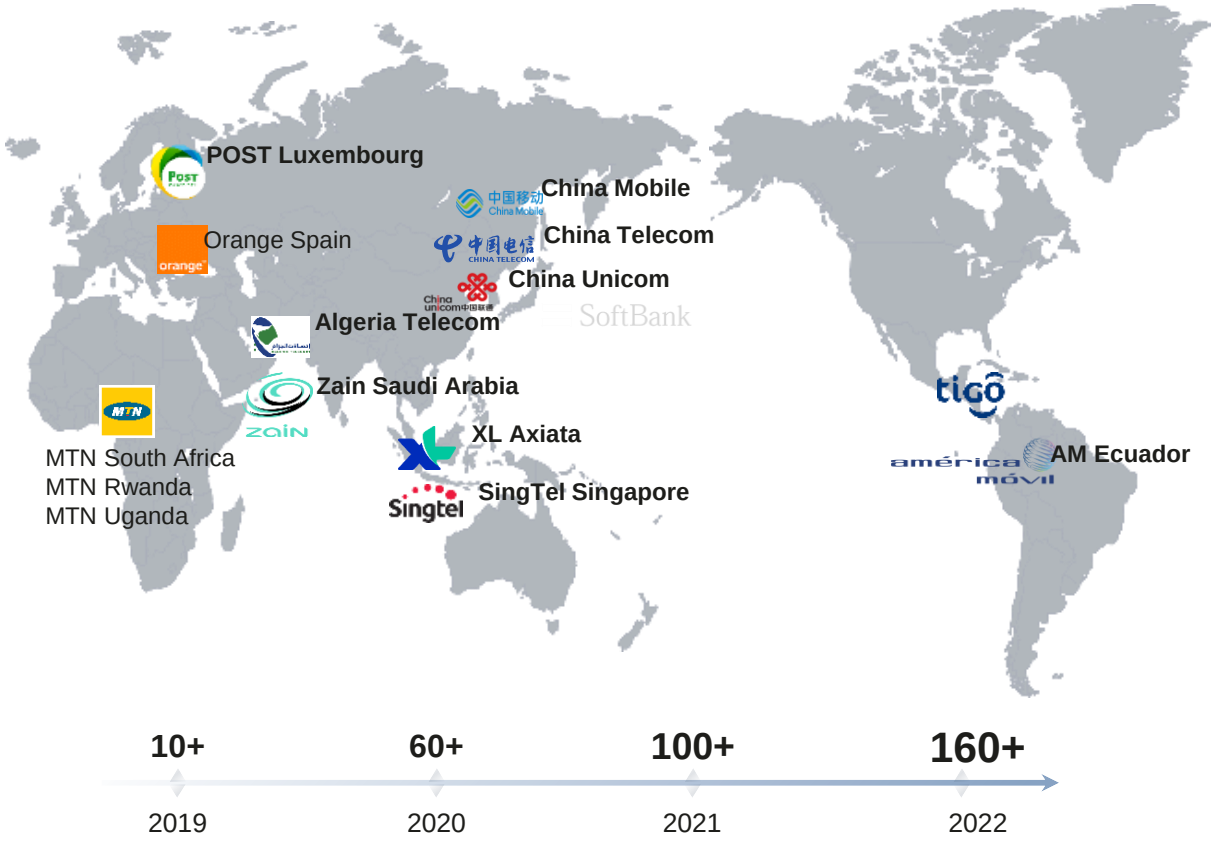
EANTC Continuous SRv6 Inter-op Test (2018 – 2023)

Record-Speed SRv6 Deployment in Global Carriers

Global Carriers Consensus
(Part of the list)

orange	✓Orange Spain Deployed
T··	✓2 Round RFP Released
Telefónica	✓Brazil VIVO IOT Trial
swisscom	✓Already Deployed
中国移动 China Mobile	✓24 Network Deployed
SoftBank	✓SRv6 Flex-Algo on 5G Commercial Network
MTN	✓Already Deployed in 3 countries‘
zain	✓Already Deployed in 2 countries‘

Global SRv6 Cases



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Implementation of SRv6 Dual-Vendor Interworking

Challenges

1. Network evolution is complex

   IP Network of Orange Spain is built by Huawei, Cisco, Nokia and Juniper.

2. 5G network optimization is complex

   Manual optimization based on MPLS/RSVP-TE is complex and takes several days.

Requirements

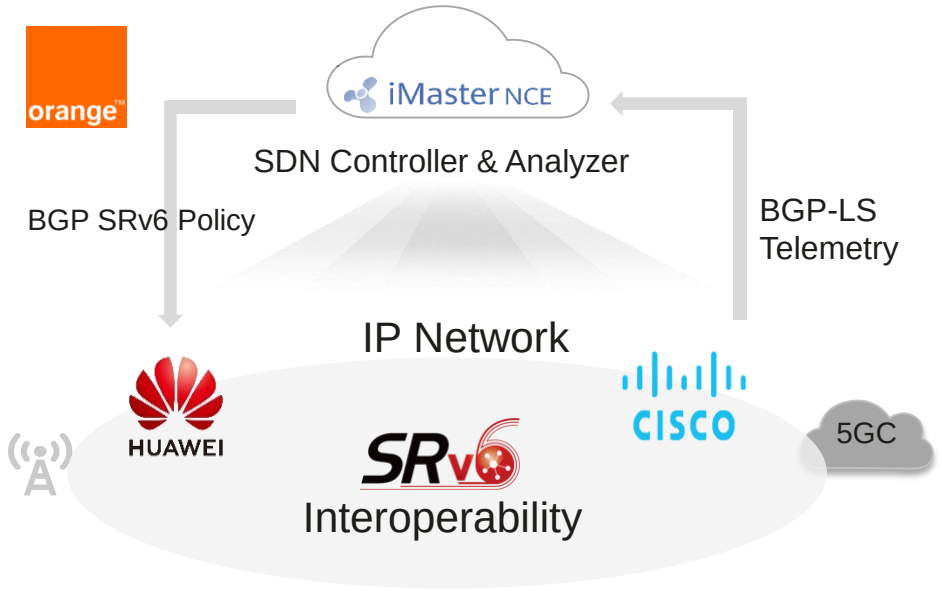
1. Target network architecture for future

- Future services oriented target network
- Evolvable protocol by multi-vendors

2. Flexible network optimization

- Easy network optimization

Implement SRv6 Interworking



Service Scope	Standard Solution		Interworking
5G / LTE SRv6 BE/Policy	IGP TOPO	IS-IS v6 BGP-LS	Huawei ATN/NE PE Node, SRv6 Support
2G / 3G MPLS/RSVP-TE	Forward Control	SRv6 BGP-SR	Cisco NCS P Node, SRv6 Support

Benefit: Flexible Optimization

Flexible path optimization on demand

Automation
improve
O&M efficiency

Optimization
average latency
reduce 16ms

We expect in 2023 that all the equipments will have a renewal.
— Hector Llorente
IP & Transport Network Manager, Orange Spain

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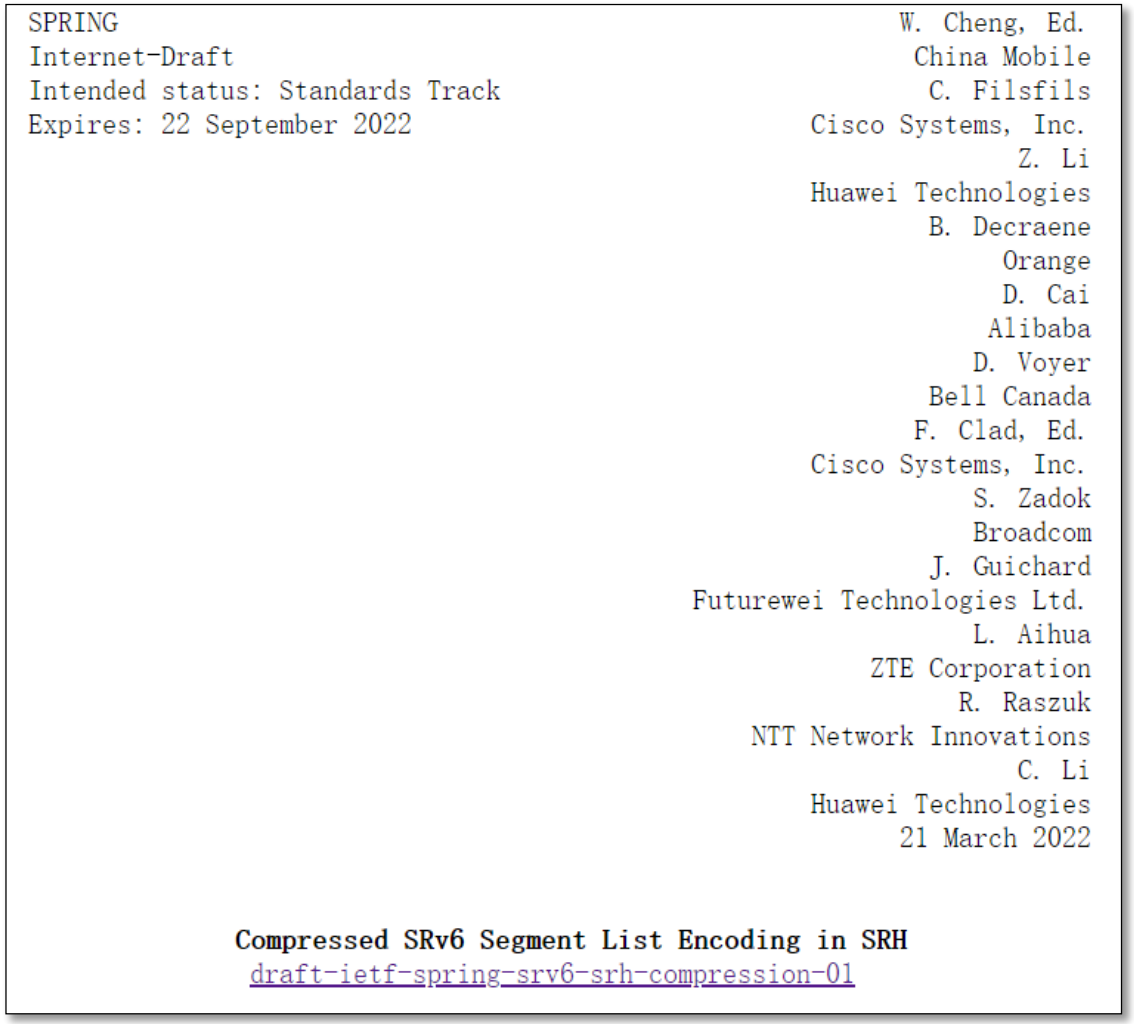
SRv6 Compression: Converged Single Solution and C-SID draft adopted by WG

IETF SPRING WG

- draft-ietf-spring-srv6-srh-compression(C-SID) is adopted.
- C-SID draft defines flavors for the SR endpoint behaviors, which enable a compressed SRv6 Segment-List encoding in the Segment Routing Header (SRH).
  - Replace-C-SID Flavor a.k.a G-SRv6
  - Next-C-SID Flavor a.k.a uSID
  - Next-and-Replace-C-SID Flavor
- All the flavors are defined under the SRv6 network programming architecture RFC8986.
- Replace-C-SID flavor SID and Next-C-SID can be encoded in a single SRH for better interop, and the interop test had been done in 2020.



SPRING
Internet-Draft
Intended status: Standards Track
Expires: 22 September 2022

W. Cheng, Ed.
China Mobile
C. Filsfils
Cisco Systems, Inc.
Z. Li
Huawei Technologies
B. Decraene
Orange
D. Cai
Alibaba
D. Voyer
Bell Canada
F. Clad, Ed.
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S. Zadok
Broadcom
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Futurewei Technologies Ltd.
L. Aihua
ZTE Corporation
R. Raszuk
NTT Network Innovations
C. Li
Huawei Technologies

21 March 2022

Compressed SRv6 Segment List Encoding in SRH
draft-ietf-spring-srv6-srh-compression-01

C-SID is the recommended solution as per the Design Team's analysis result, which meet all the compression reqs

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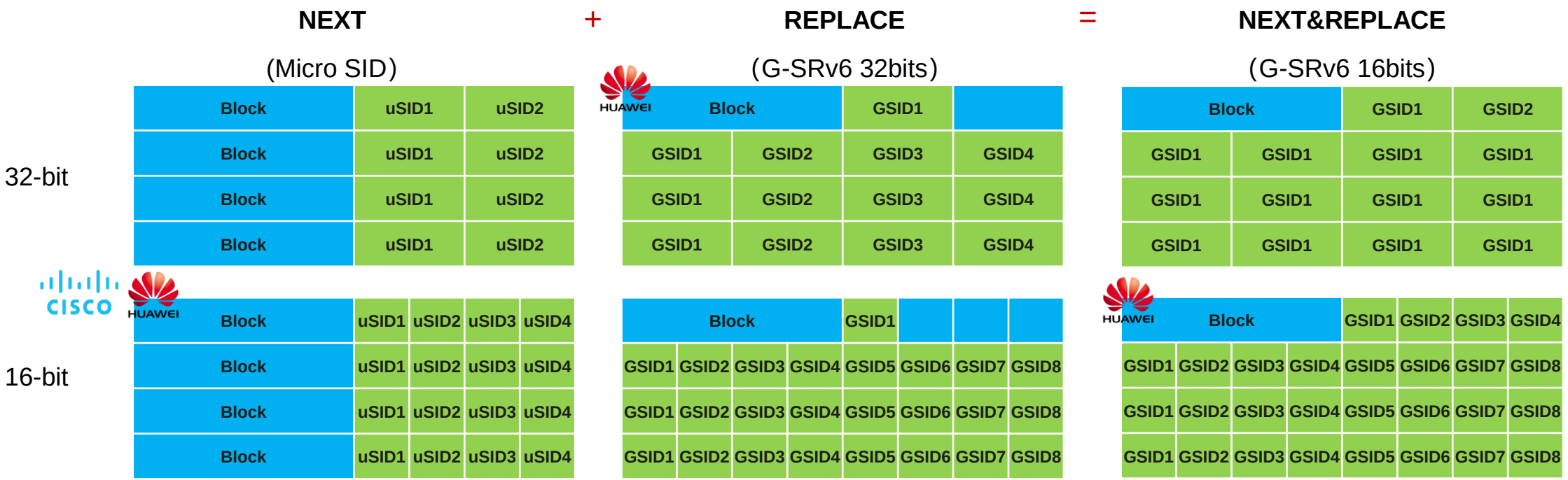
Huawei Implementations on SRv6 C-SID Solutions for Full Applicaiton Scenarios



Small locator block, best compression ratio for limited SID list

Flexible locator block, balanced compression ratio and scalability

Flexible locator block, best compression ratio for any SID list

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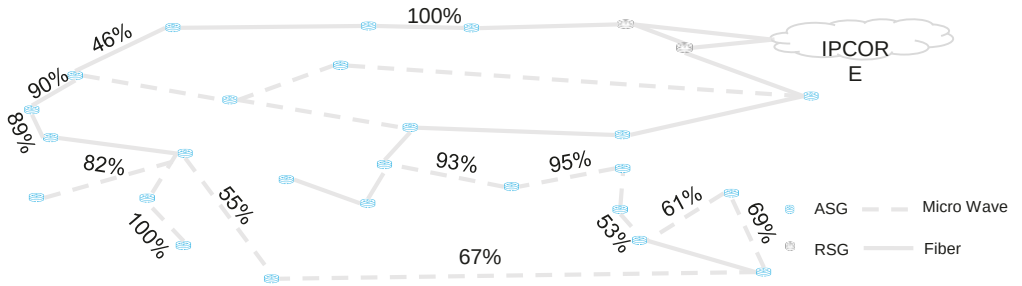
Deployment of SRv6 Compression to Promote Rapid Traffic Growth

High BW Usage and Insufficient Available Resources



--Typical Aggregation Ring Topology of From Operator U

- To much microwave link: 50% for aggregation(15/30) and 80% for access
- Long service path: 4 aggregation rings have 60 NE on average, and 52 access rings have 8 NE on each ring. **The service path is 17 hops on average.**
- High bandwidth utilization: 70% on average and over 90% in some cases

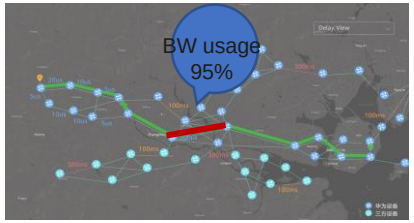
Key Challenge: How to ensure smooth SRv6 cutover without network-wide capacity expansion?

Long service path	High bandwidth utilization	To much microwave link
SRv6 packet carry path info Bandwidth usage definitely increases with SRv6. The longer the path the larger the packet size	High risk of rash cutover Large investment in network expansion unaccepted	The available bandwidth resources is insufficient

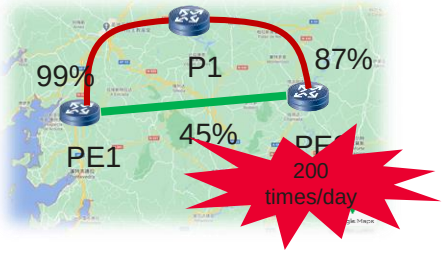
Challenge: How to ensure smooth SRv6 cutover without network-wide capacity expansion?

GSRv6+SDN+precise expansion supports SRv6 successfully deployed

GSRv6 +



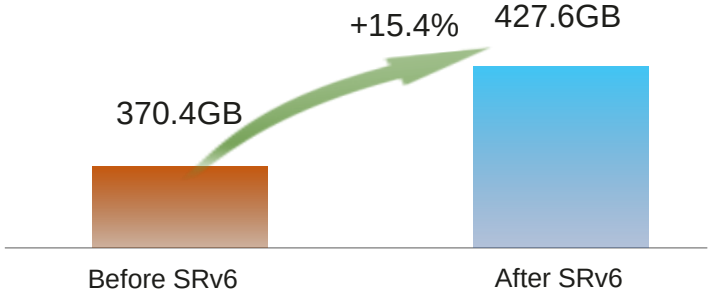
+



Measure 1: Reduce the SRv6 header size with GSRv6

Measure 2: Identify network bottlenecks and perform precise expansion.

Measure 3: SRv6 Based SDN UC Real-time automatic optimization ensuring optimal paths at any time



After SRv6 is deployed in area N
Suppressed traffic is rapidly released

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IOH Completed SRv6 Micro-SID Interoperability Test

Huawei & Cisco IOH SRv6 Interoperability Test Success

15+	100%	Excellent
Complete cases	Pass rate	Test effect

SRv6 Brings Great Value to IOH Network

41% ↓	35% ↑
Transmission overhead reduce	Forwarding efficiency improve

Outstanding Contribution to Regional IPv6 Innovation

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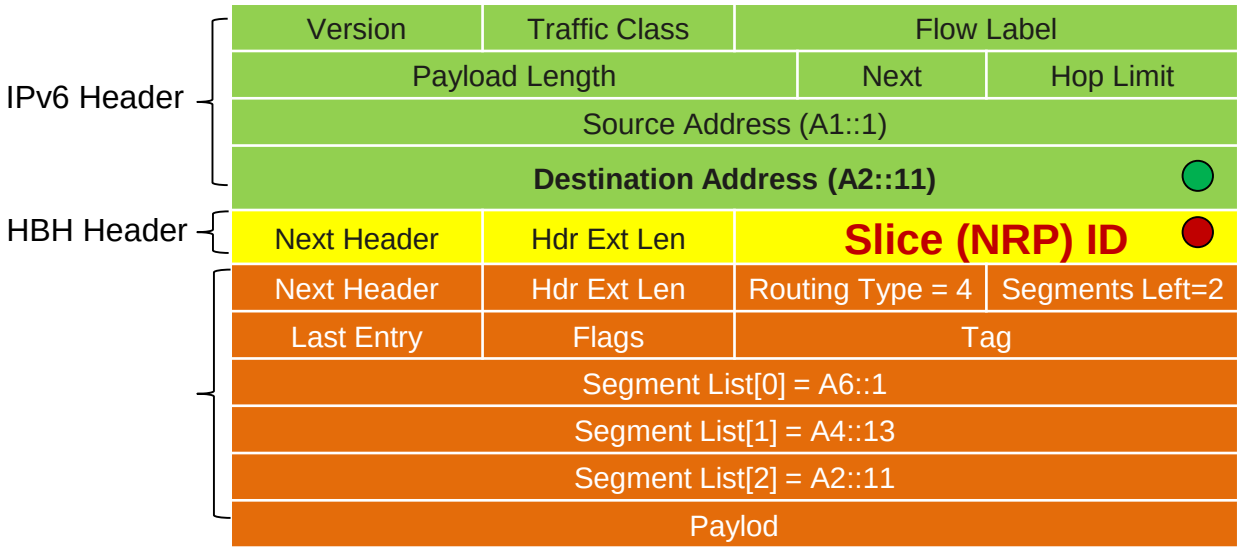
IPv6 Encapsulation for Network Slicing

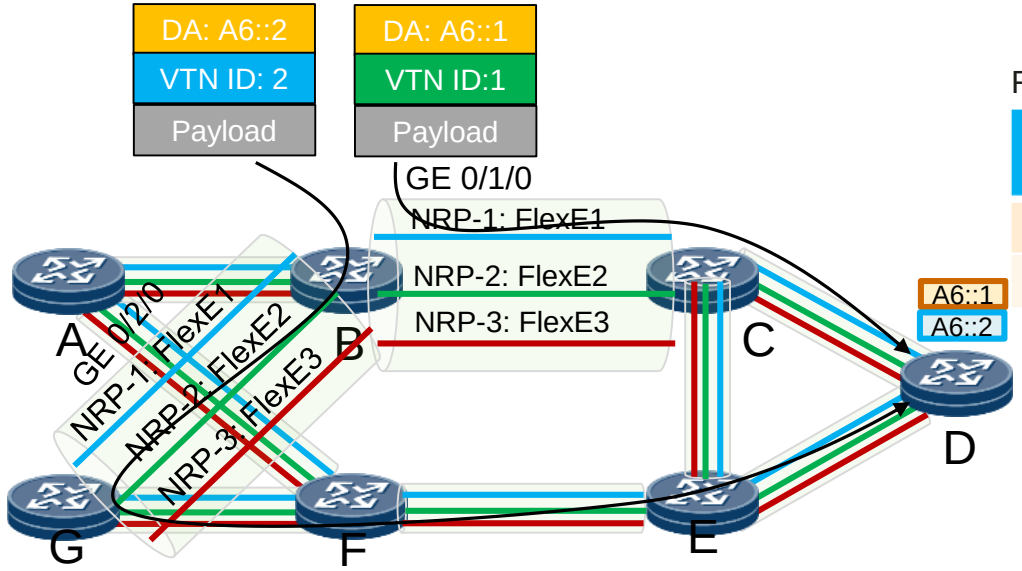


Makes use of two separate data plane identifiers for topology and resource specific forwarding treatment

- Use IPv6 destination address to determine the next-hop and outgoing interface in the specified topology
- Use NRP ID field to determine the network resource for packet processing & forwarding

Benefits of this approach:

- Decouple the topology/path identifier and the resource identifier in data packet
- Reduce the number of SRv6 Locator/SID needed for slicing, improve scalability



Forwarding table of node B:

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 NRP-ID Extensions : *tools.ietf.org/html/draft-dong-6man-enhanced-vpn-vtn-id*

IPv6 Network Slicing Deployment Cases

80+ Network Slicing deployments worldwide

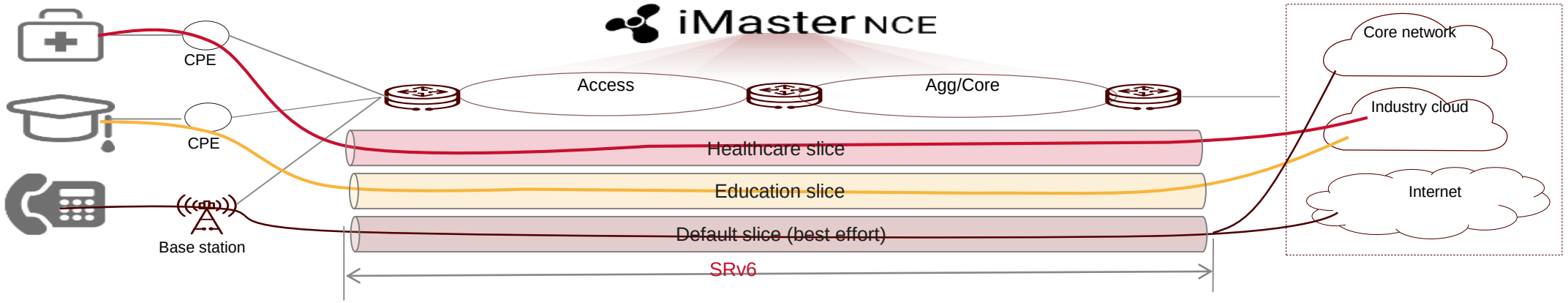
- Multi-industrial network
- Fix-Mobile Convergence
- Premium Private Lines …
- Multi-service networks …

Operator N: Network Slicing for Multiple Vertical Industrials

Healthcare

Education

Public Internet



Please refer to visit draft-ma-teas-ietf-network-slice-deployment for details

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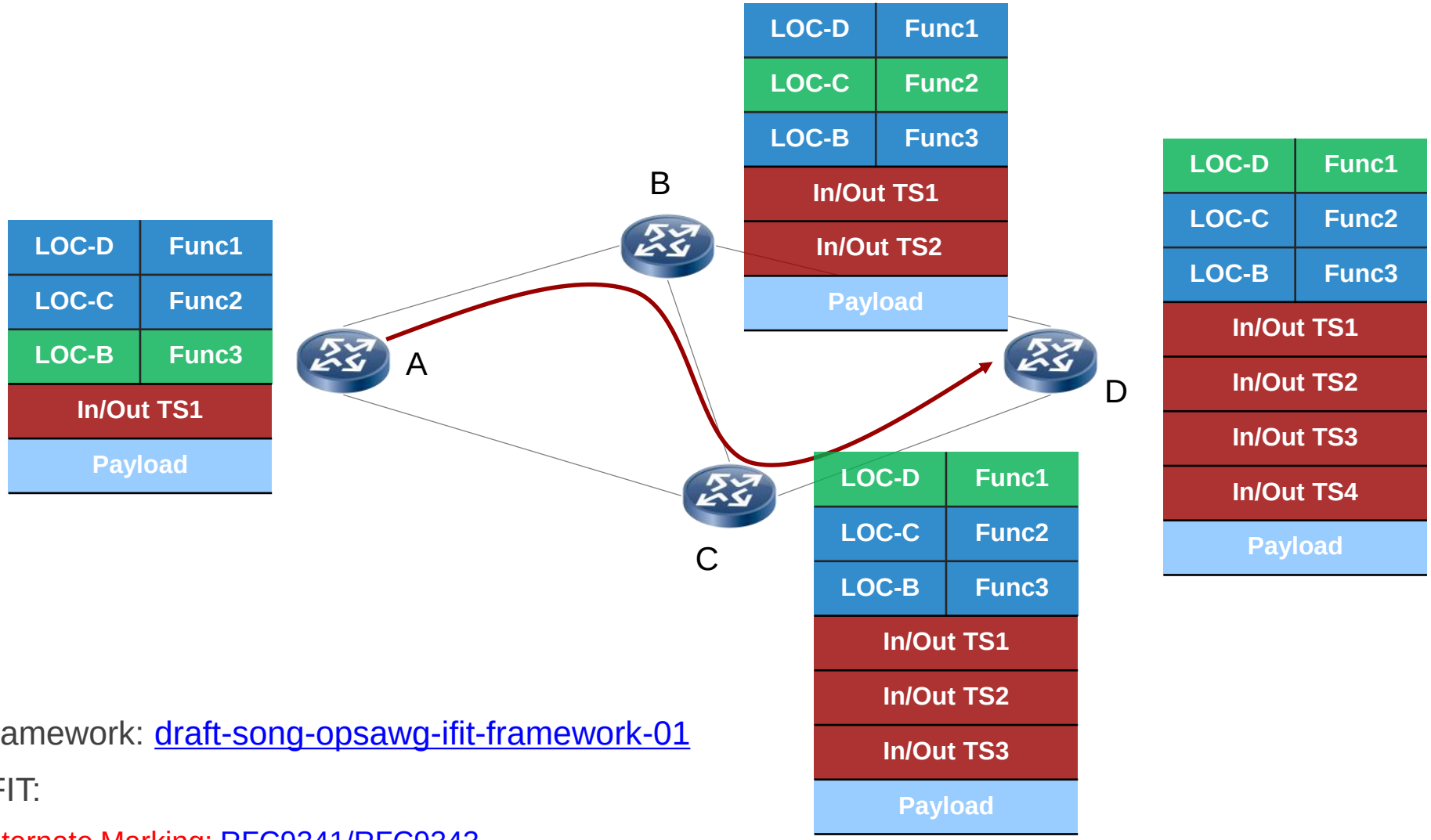
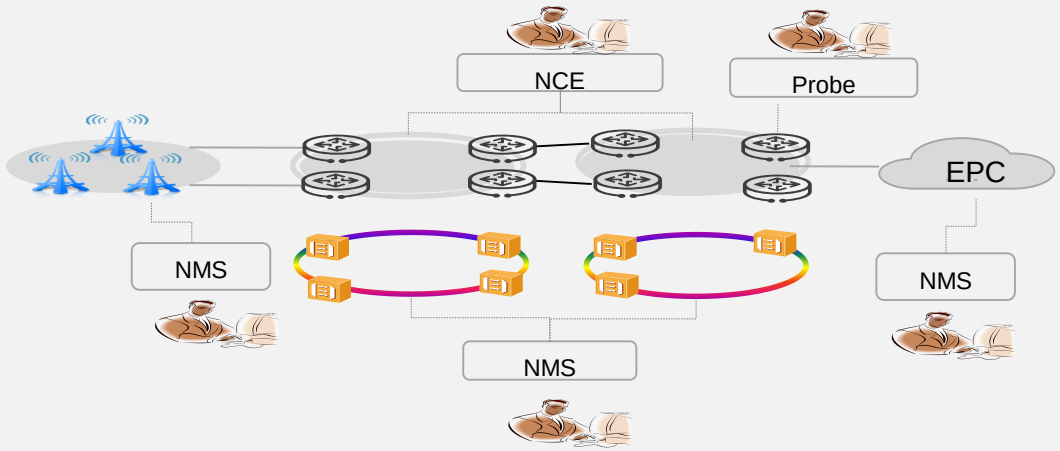
IPv6 IFIT (In-situ Flow Information Telemetry)



- IFIT Framework: draft-song-opsawg-ifit-framework-01
- IPv6 IFIT:
  - Alternate Marking: RFC9341/RFC9343
  - IOAM: RFC9197/RFC9326 and draft-ietf-ippm-ioam-ipv6-options

IPv6 IFIT Deployment Cases: Wireless Service SLA Visualization/Awareness/Fault Locating

Multi-Independent O&M teams/systems for wireless, core, and bearer networks



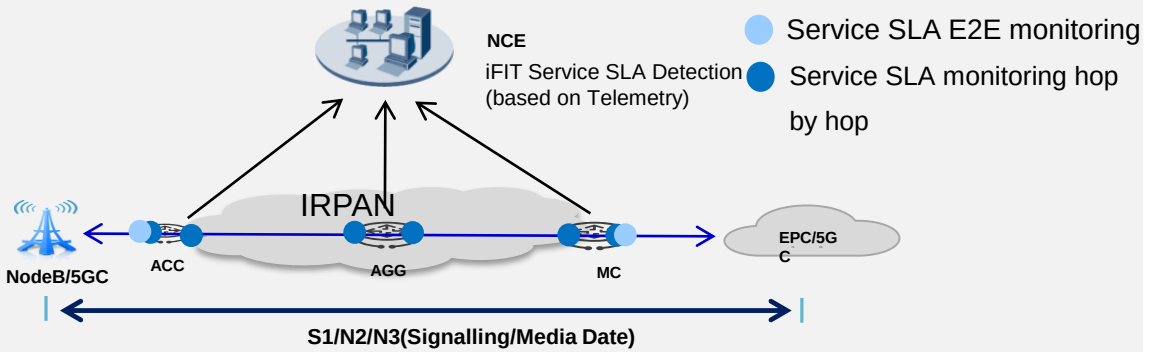
Pain points:

E2E fault locating involves multiple teams, making fault demarcation difficult and Low efficiency.

- ✓ Difficult demarcation: deployed Interval test packets solution, the network cannot prove its innocence when fault occurs.
- ✓ Difficult fault locating: The efficiency of locating the network fault point is low, resulting in poor user experience.

1. Service SLA E2E visualization/perception proactively

2. For poor-quality services, NCE automatically starts hop-by-hop precise demarcation and displays the demarcation result, helping quickly locate faults.



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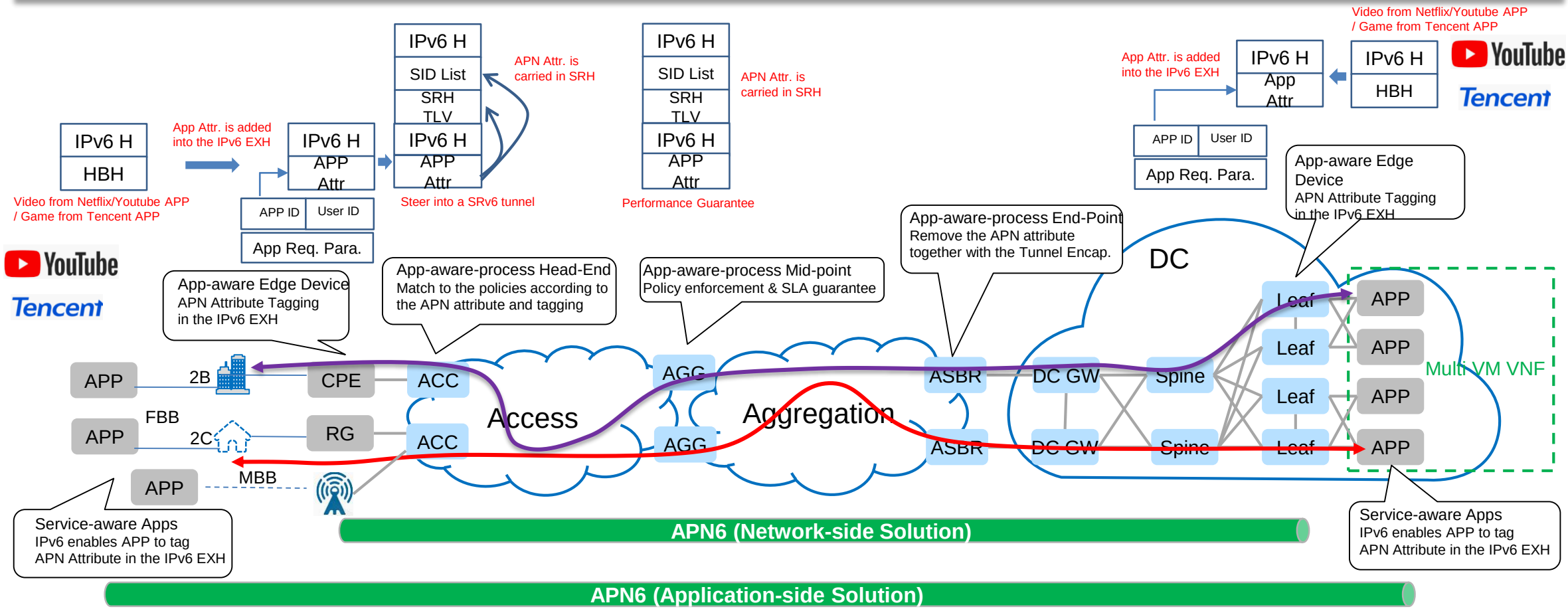
APN6: Application-aware IPv6 Networking

- Make use of IPv6 extensions header to convey APN attribute along with the packets into the network
- To facilitate the flexible policy enforcement and fine-grained service provisioning



https://datatracker.ietf.org/doc/draft-li-apn-framework/
https://ieeexplore.ieee.org/abstract/document/9162934

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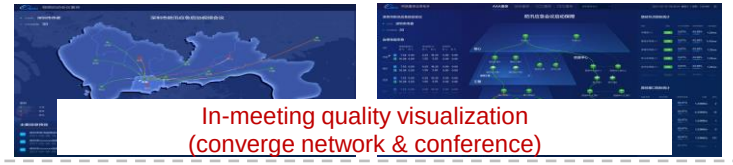
APN6 Demo Cases: Improve User Experience of Video Conference in 2B Services

APN for service-aware, Slicing for SLA ensurance, IFIT for E2E visualization

Mgmt Layer

1 Operation platform (iMOC)



Ctrl Layer

CloudVC (SMC) — iMaster NCE — Network Controller (NCE)

Physical Layer

VC Terminals: IdeaHub, CloudLink Box, HW CloudLink software, OpenHarmony HarmonyOS

Campus Network: VC slice, IoT slice, OA slice

Core Network (IPv6 Enhanced, IP & Optical): 2 VC slice, IoT slice, OA slice

Cloud: Data Center, CloudVC (MCU), OpenEuler EulerOS

Service Layer

2 Carry APN identifier — Conference Media Traffic

3 iFIT provides per-Hop telemetry in real time

SRv6 auto-setup. Flex-E slices provide SLA guarantee.

Conference Media Traffic — Carry APN identifier

ICT Product

User Equipment	Network	Cloud
VC Terminals (Harmony OS)	Network (router & switch) IP & Optical (transport)	iMOC, NCE, CloudVC (EulerOS)

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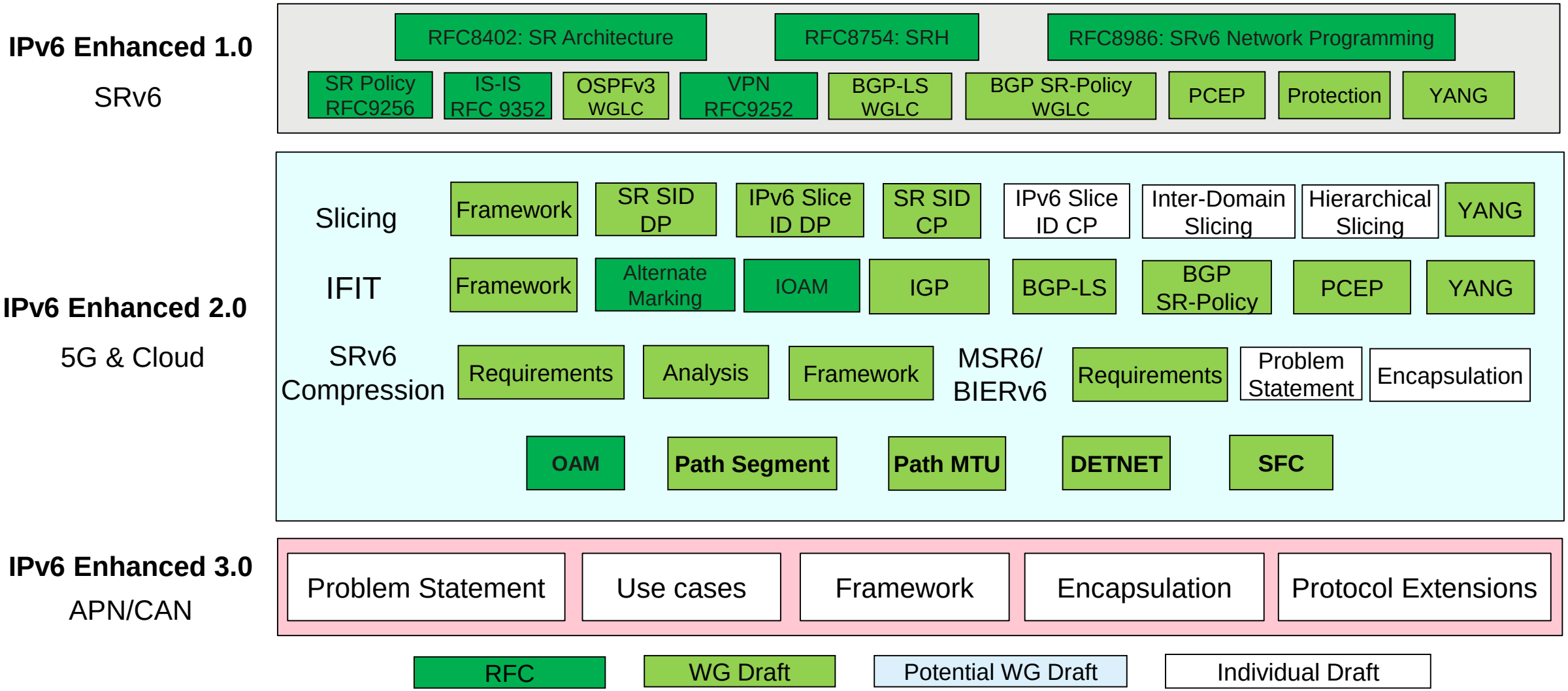
Summary of Usage of IPv6 Extension Headers

Functionalities	RFC/Drafts	IPv6 Extension Header		
		HBH Header	Routing Header	DO Header
SRv6	RFC8754		√	
VPN+ (Network Slicing)	1. draft-ietf-spring-resource-aware-segments 2. draft-ietf-6man-enhanced-vpn-vtn-id	√	√	
IFIT (In-situ Flow Telemetry)	1. RFC9197 2. RFC9326 3. RFC9341/RFC9343	√	√	√
MSR6/BIERv6	1. draft-lx-msr6-rgb-segment 2. draft-geng-msr6-traffic-engineering		√	√
APN6	1. draft-li-apn-header 2. draft-li-apn-ipv6-encap	√	√	√

IETF Standardization Work Layout



Please visit www.ipv6plus.net for the latest progress

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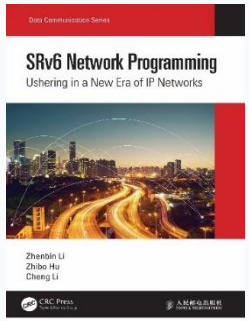
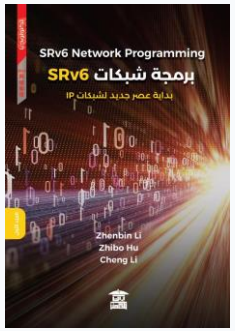
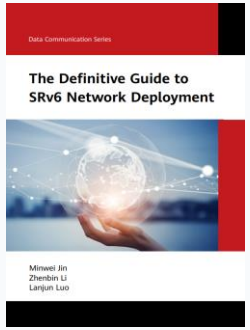
IPv6 Enhanced Series Books and Videos

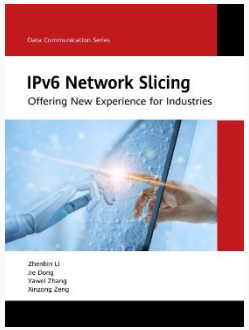
IPv6 Enhanced Books





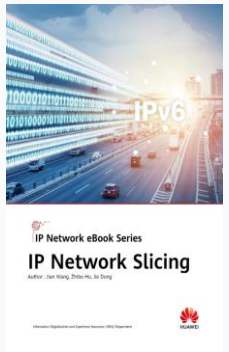
To be published in 2023





https://www.amazon.com/SRv6-Network-Programming-Ushering-Communication/dp/1032016248

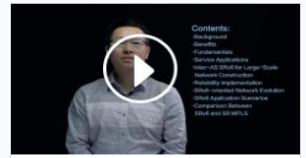
IPv6 Enhanced Series e-Books



IPE Series eBook

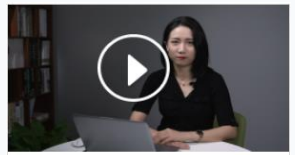
Scan to obtain the electronic version

IPv6 Enhanced Series Videos



(Video) IP New Technology Series (Advanced) - Segment Routing IPv6 (SRv6)

(Video) IP New Technology Series (Advanced) - Segment Routing MPLS (SR-MPLS)



(Video) IP New Technology Series (Advanced) - Deep Dive into Ping & Tracert for SRv6

(Video) IP New Technology Series (Advanced) - Deep Dive into EVPN L3VPNv4 over SRv6 TE Policy

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

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Thank You