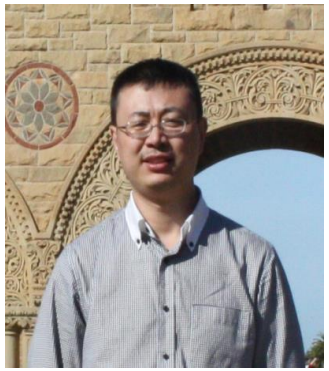
IPv6+: A New Era of IP Networks for 5G and Cloud

Zhenbin Li
Huawei Chief IP Standard Representative
IETF Internet Architecture Board Member



Zhenbin (Robin) Li

IETF Internet Architecture Board (IAB) Member
https://www.iab.org/about/iab-members/

- 15+ years research and development work in IP Operating System 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.

Rethinking on Internet

- **Lesson of IPv4: Scalability**
- **Lesson of IPv6: Compatibility**
  - SRv6 is compatible with IPv6 forwarding.
  - SRv6 is compatible with MPLS forwarding.
- **Success of All IP 1.0**
  - MPLS plays an important role.
  - SRv6 must inherit 3 advantages of MPLS firstly: VPN; FRR; TE.
- **Challenges of All IP 1.0**
  - 1. Isolation of Network Domains owing to Islands of IP Transport Network.
  - 2. Limited space of encapsulation of IPv4 and MPLS for programmability for new services.
    - IPv4: IPv4 Options are not implemented.
    - MPLS: Fixed length and fixed fields.
  - 3. Networking on its own owing to decoupling application and network transport.
    - ATM to Desktop: Failed.
    - MPLS to Cloud: Failed

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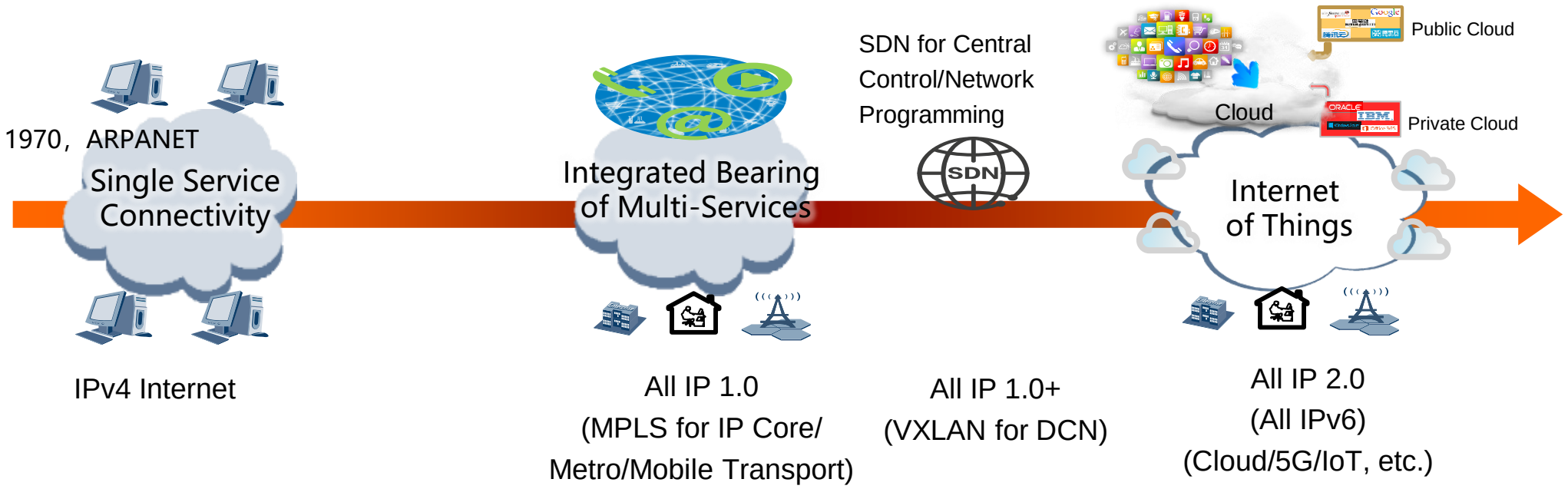


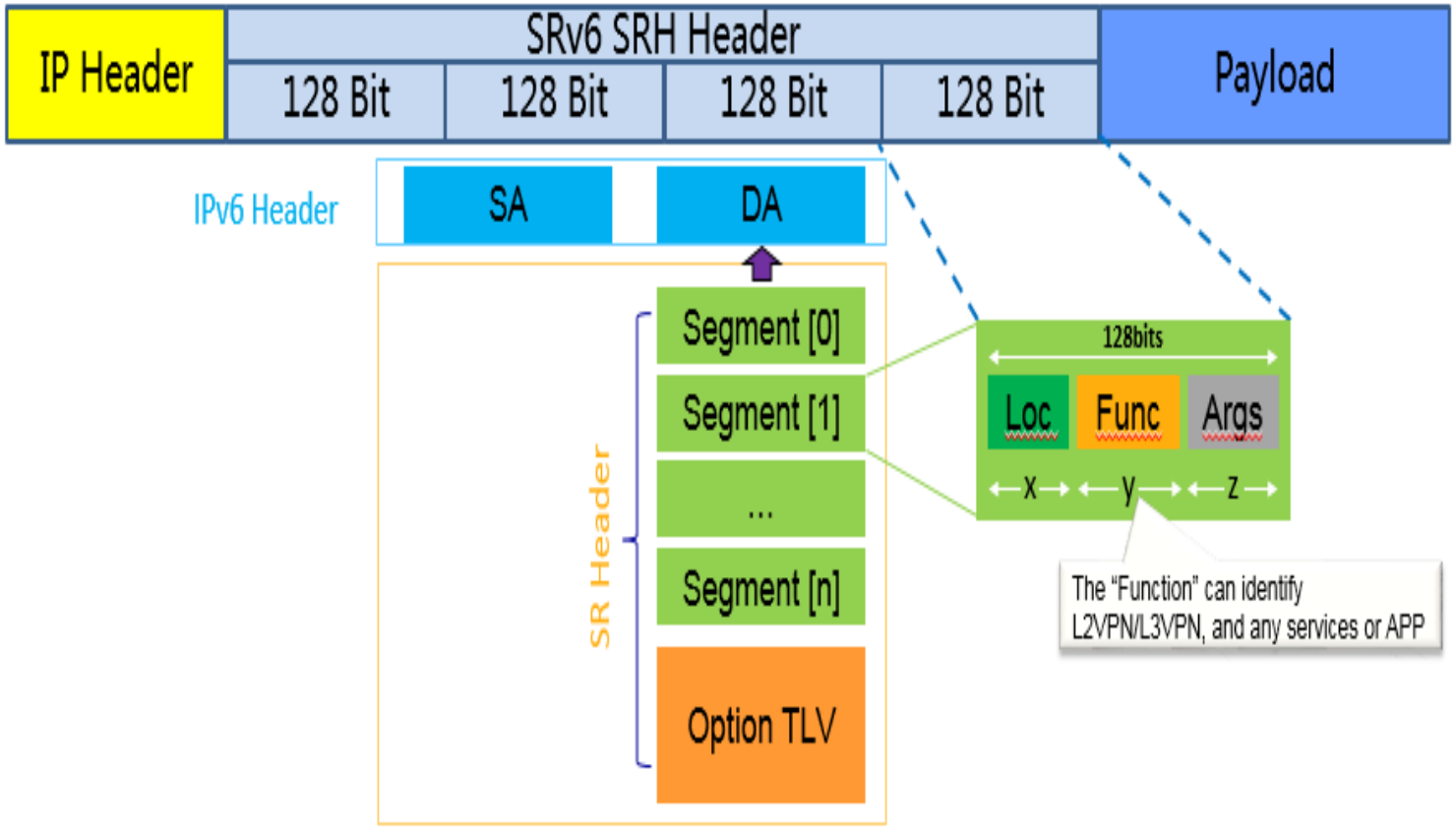
- Rethinking on IPv6: Address Space is not enough.
- Mission of IPv6+:
  - Integrate different network easier based on affinity to IP reachability.
  - Provide more encapsulations for new network services such as Network Slicing, DetNet, etc.
  - Cross the chasm between application and network based 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



IPv6+ Research and Standard Planning

IPv6+ 1.0： SRv6 Basic Capabilities

- SRv6 VPN
- SRv6 TE
- SRv6 FRR

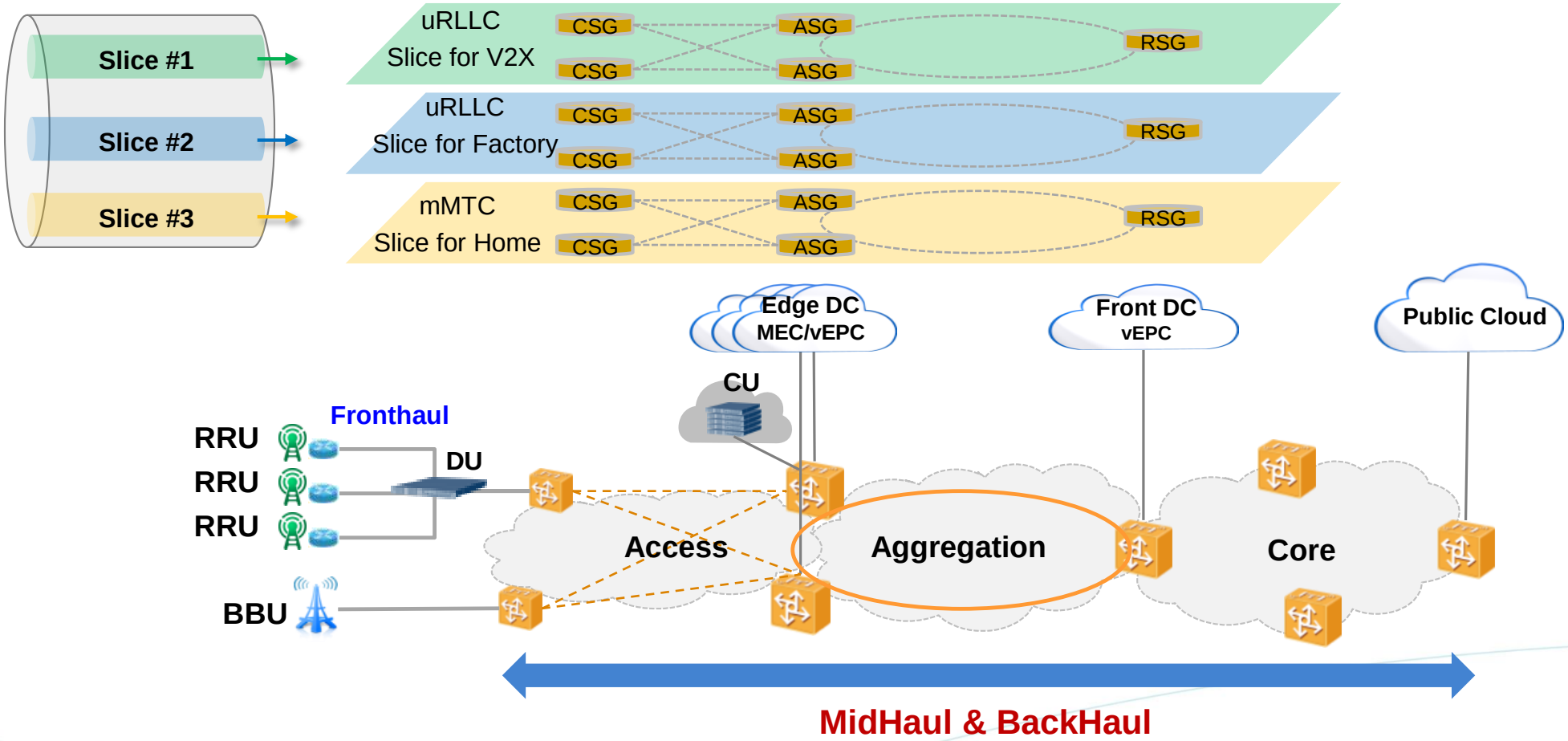
IPv6+ 2.0 ： New Network Services for 5G/Cloud

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

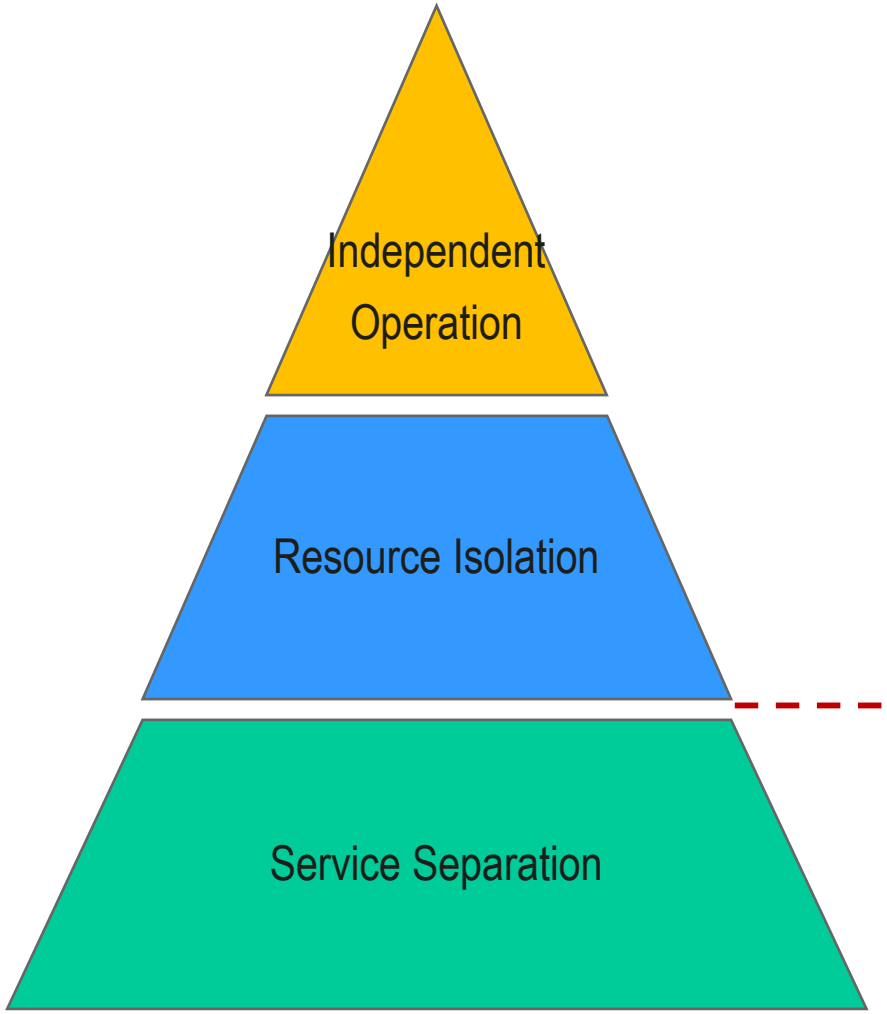
IPv6+ 3.0： APN6 – App-aware network architecture

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

5G Transport Network Slicing



Transport Network Slicing Requirements



Level 3 – Independent Operation

- Independent management plane for on-demand provisioning of network slices
- For wholesale or self-operated vertical services

Level 2 – Resource Isolation

- Dedicated resource ensures no interference between network slices
- For 5G critical services with demanding performance

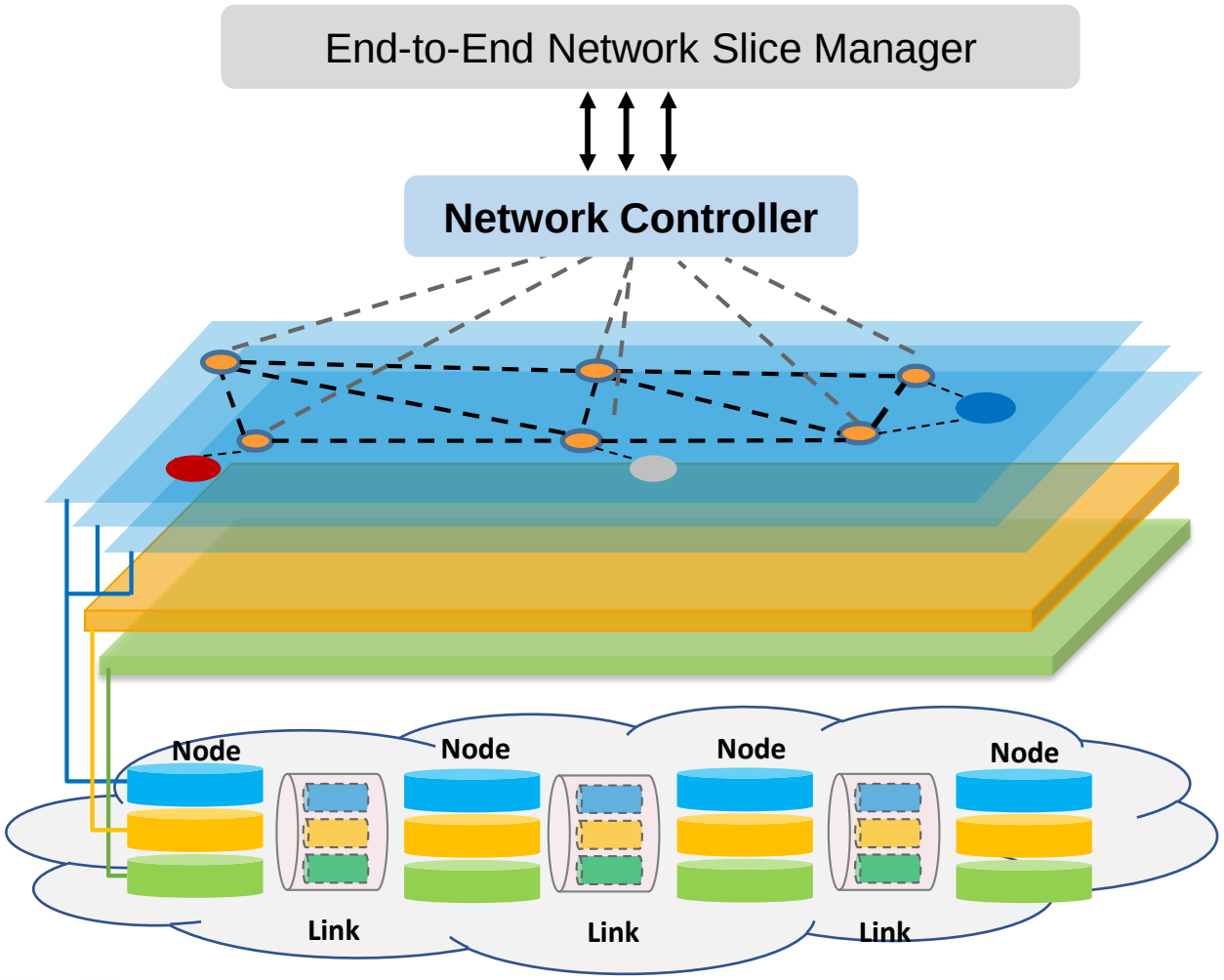
Addressed by Enhanced VPNs

Level 1 – Service Separation

- Isolation in service access & connectivity
- Possible interference between services
- For traditional enterprise services

Addressed by Existing VPNs

VPN+ Network Slicing Architecture



Network Slice Management

- Dynamic/automatic network slice life-cycle management
  - Creation, monitoring, adjustment, deletion
- Network slice planning algorithms

Network Slice Instantiation

- Customize network slice topology and associated attributes
- Integration between overlay connectivity and underlay resource

IPv6+ enabled

Network Resource Partitioning

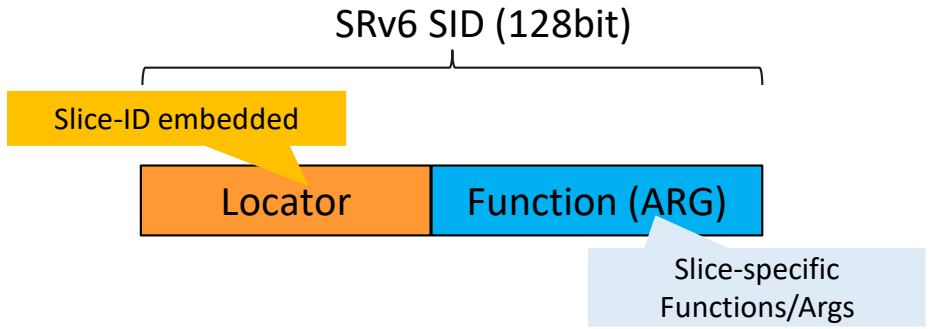
- Physical interface
- Flexible Ethernet (FlexE)
- Logical sub-interface
- Dedicated queues

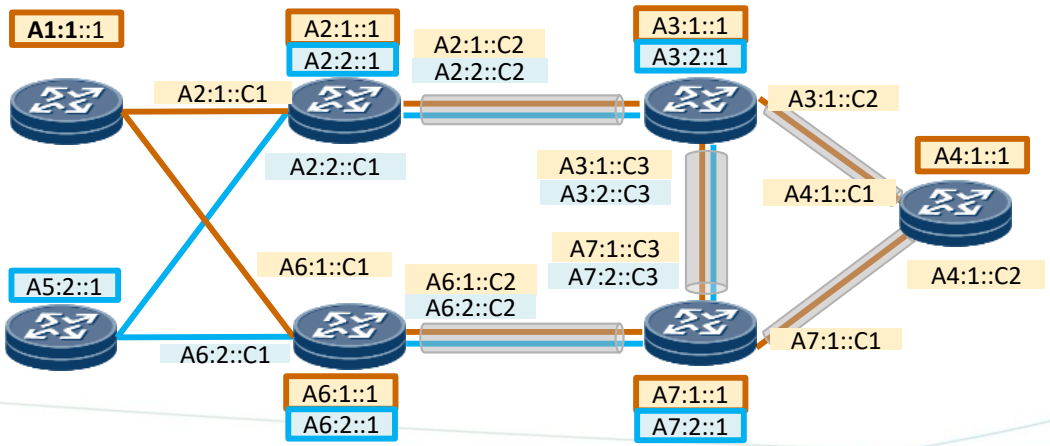
https://tools.ietf.org/html/draft-ietf-teas-enhanced-vpn

SRv6 Extensions for VPN+

Leverage SRv6 programmability for Network Slicing

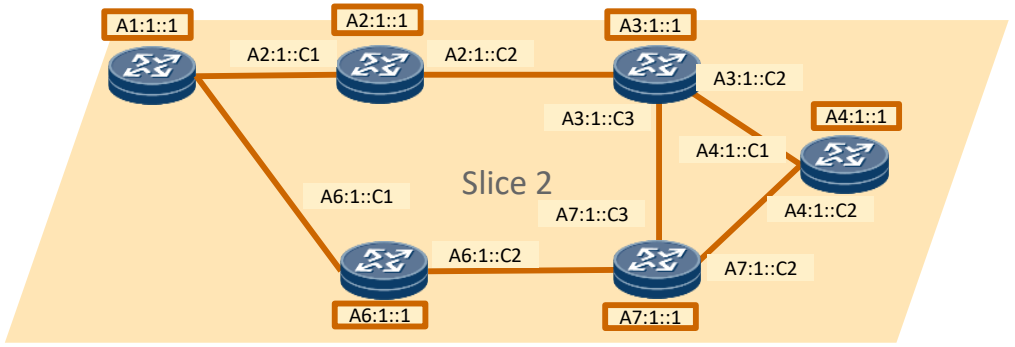
- **Network slice identification**
  - Dedicated SRv6 Locators for different network slices
  - Function & Argument can be slice-specific
  - SRv6 SIDs inherit the slice identification from Locator
- **SRv6 enhancement for network resource awareness**
  - Different SRv6 SIDs identifies network resource allocated on each segment for different network slices

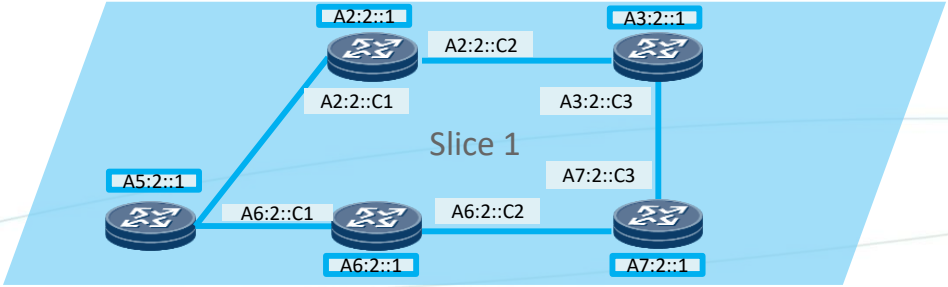




Slice 1

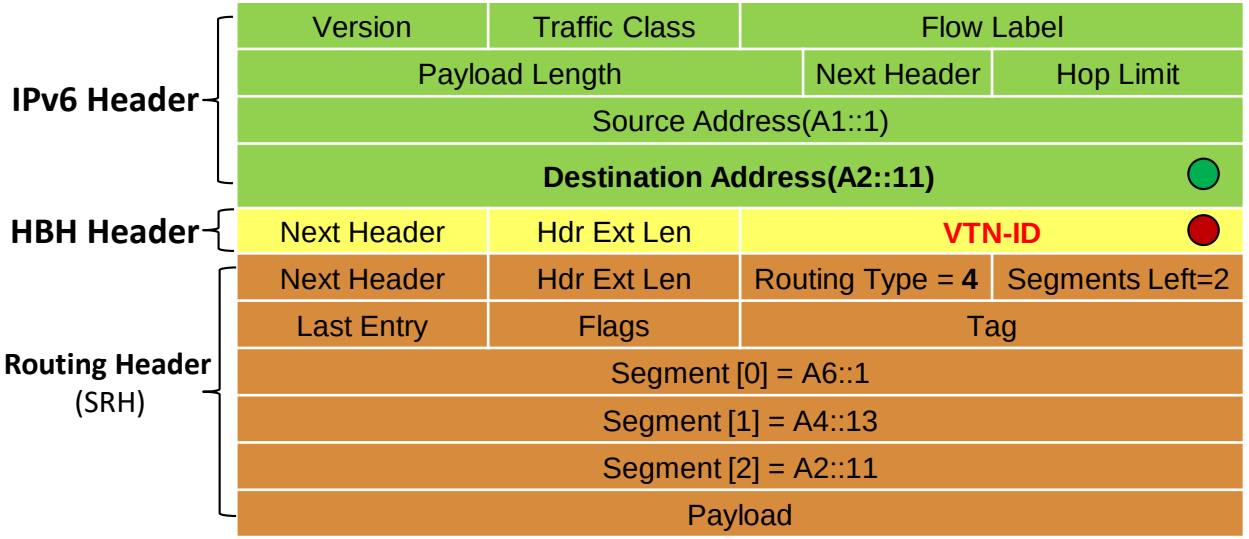
Slice 2

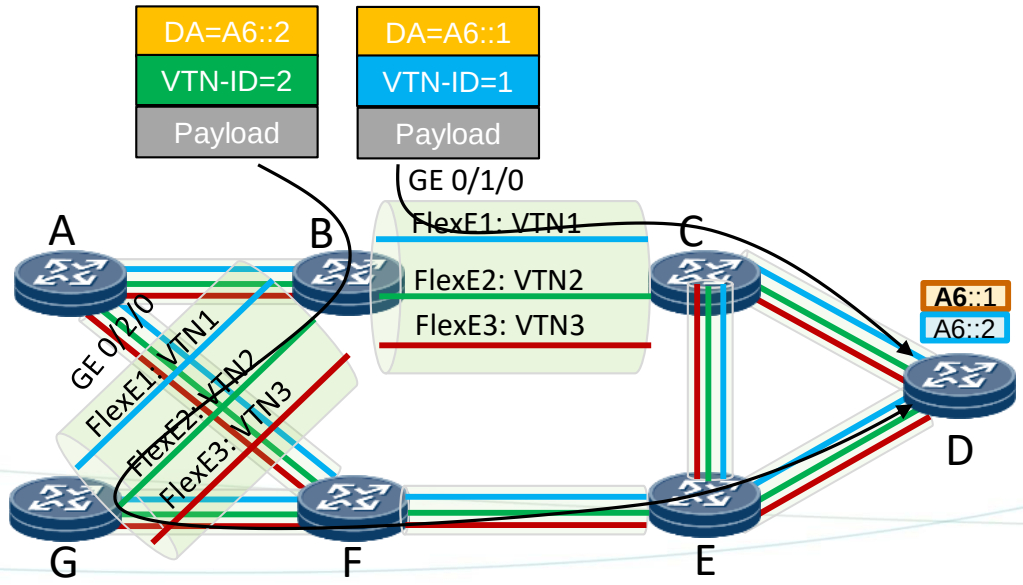




tools.ietf.org/html/draft-dong-spring-sr-for-enhanced-vpn

IPv6 Extensions for VPN+





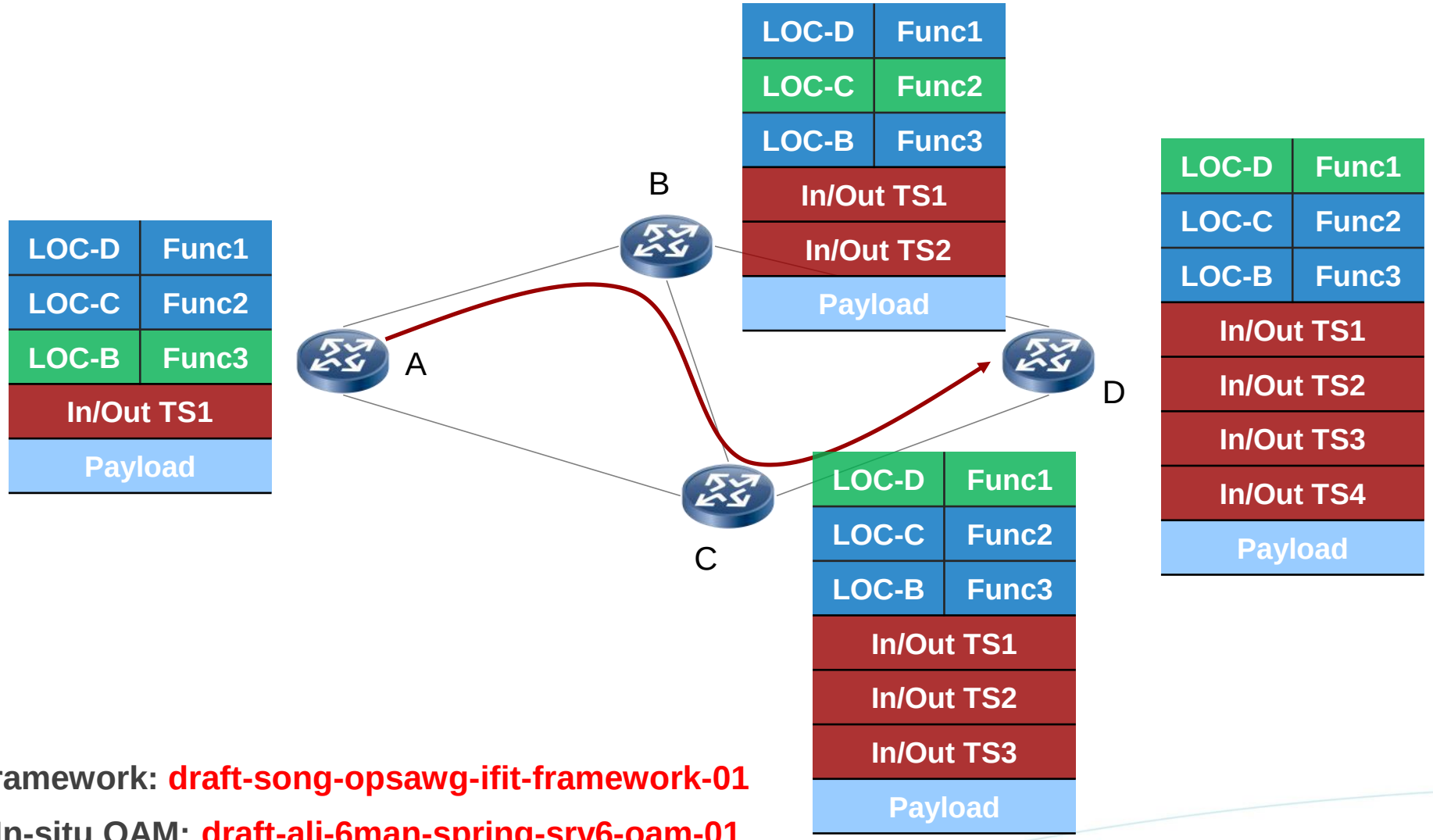
- **Two data plane identifiers for network slice specific packet forwarding**
  - IPv6 DA/SRv6 SID is used to determine the next-hop/outgoing interface within the network slice topology/path
  - VTN-ID is used to determine the sub-interface/forwarding resource allocated on the outgoing interface for a network slice
- **Advantage of IPv6 VPN+**
  - Decoupled identifiers for topology and resource specific processing
  - Reduce the amount of forwarding table entries

Forwarding Tables on 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

SRv6/IPv6 IFIT (In-situ Flow Information Telemetry)



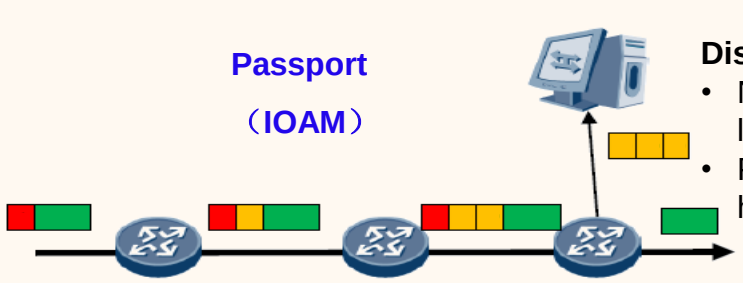
- IFIT Framework: draft-song-opsawg-ifit-framework-01
- SRv6 In-situ OAM: draft-ali-6man-spring-srv6-oam-01
- IPv6 IFIT/IOAM: draft-li-6man-ipv6-sfc-ifit-00 **IETF104@Prague**

SRV6 IFIT for Silent Failure: Enable Real-time SLA Awareness/Proactive O&M

Silent Fault Solution Key Technology Requirement：Per-packet based in band real time monitoring

◆ Industry iOAM mechanism:

https://tools.ietf.org/html/draft-ioametal-ippm-6man-ioam-ipv6-options-01

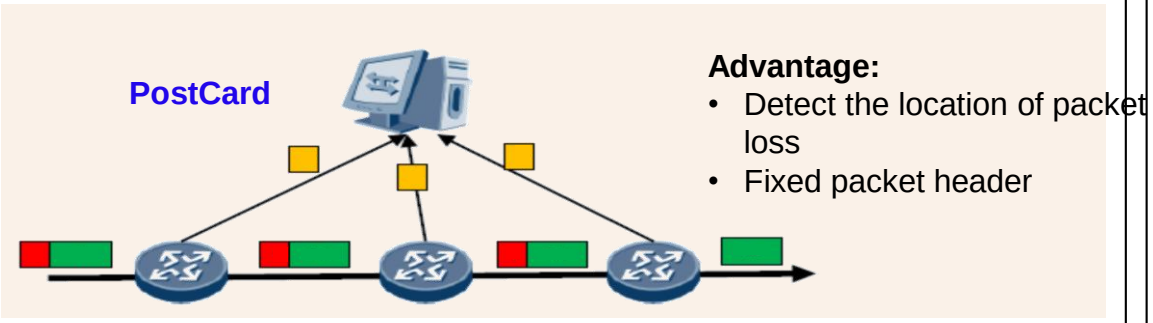


Disadvantage:
- No hop-by-hop packet loss location
- Packet header increase hop-by-hop

◆ Huawei PBT(Postcard-based Telemetry) mechanism:

https://tools.ietf.org/html/draft-song-opsawg-ifit-framework-01

https://www.rfc-editor.org/info/rfc8321 （Key technical reference）

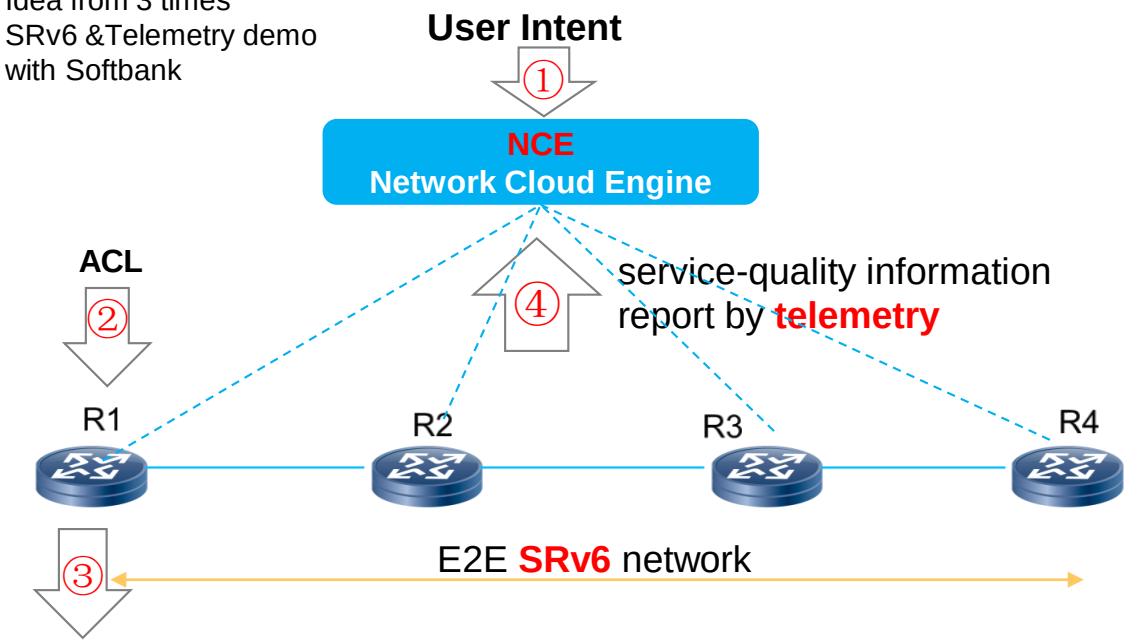


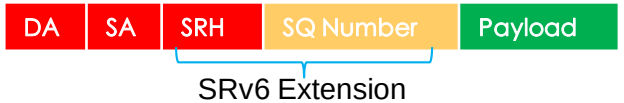
Advantage:
- Detect the location of packet loss
- Fixed packet header

instruction　Meta data　User packet

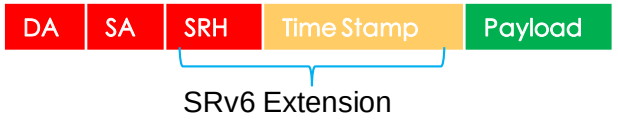
IFIT (In-situ Flow Information Telemetry) = NCE + SRv6 Programming + Telemetry

Idea from 3 times SRv6 &Telemetry demo with Softbank





Packet Loss Monitoring

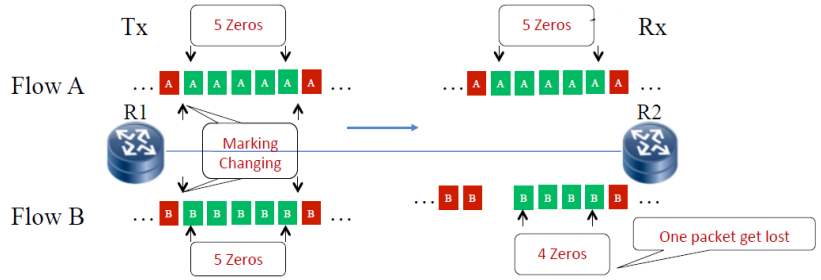


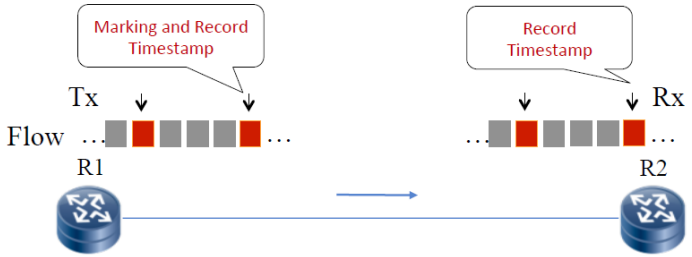
Latency Monitoring

Tokyo Interop 2019: Industry 1st launch of silent failure solution

IFIT with IPv6 Alternate Marking

Alternate Marking Method (RFC8321)



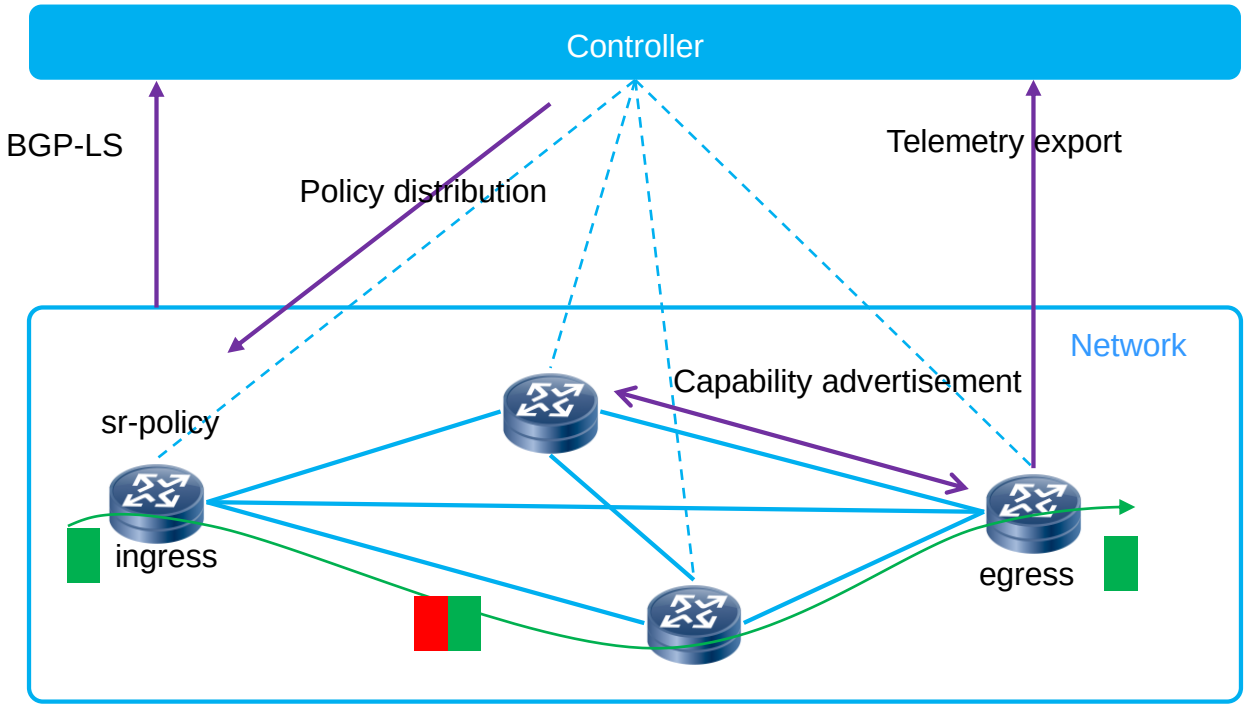


IPv6 Encap: draft-ietf-6man-ipv6-alt-mark

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                |  Option Type  |  Opt Data Len |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              FlowMonID                |L|D|     Reserved      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- HbH: for per hop monitoring
- DoH: for end to end monitoring
- DoH+RH: for specified nodes monitoring

IFIT deployment automation and interactive telemetry framework



- IFIT capability advertisement and IFIT based path computation
- SR-Policy enabled IFIT
- APN enabled IFIT
- FlowSpec enable IFIT policy

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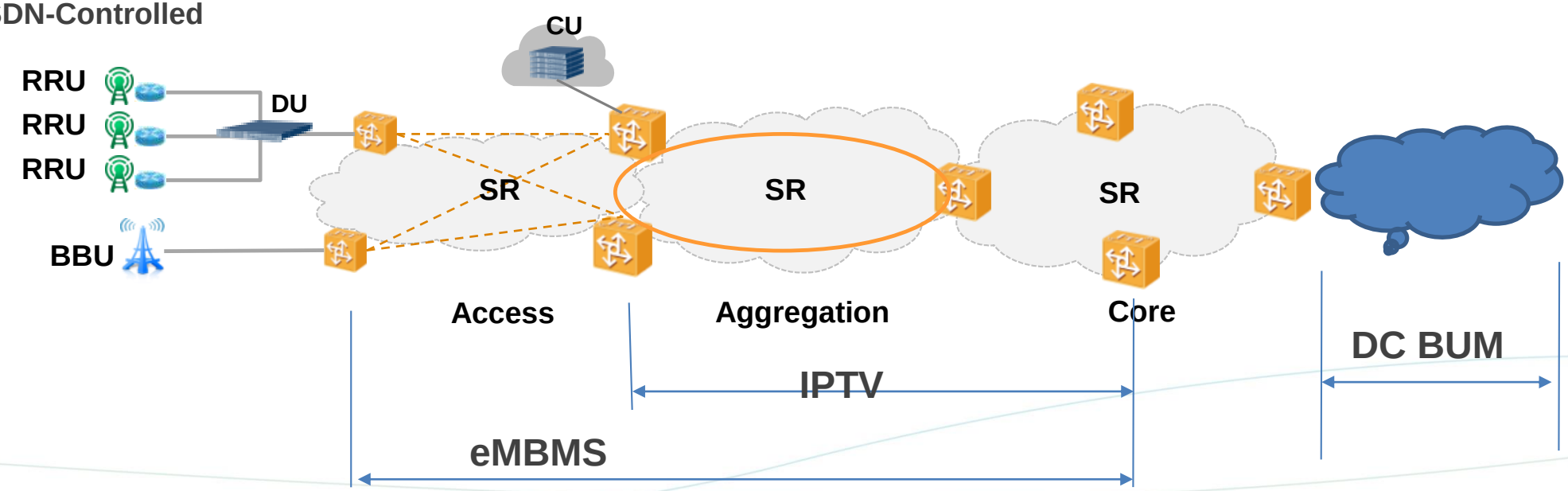
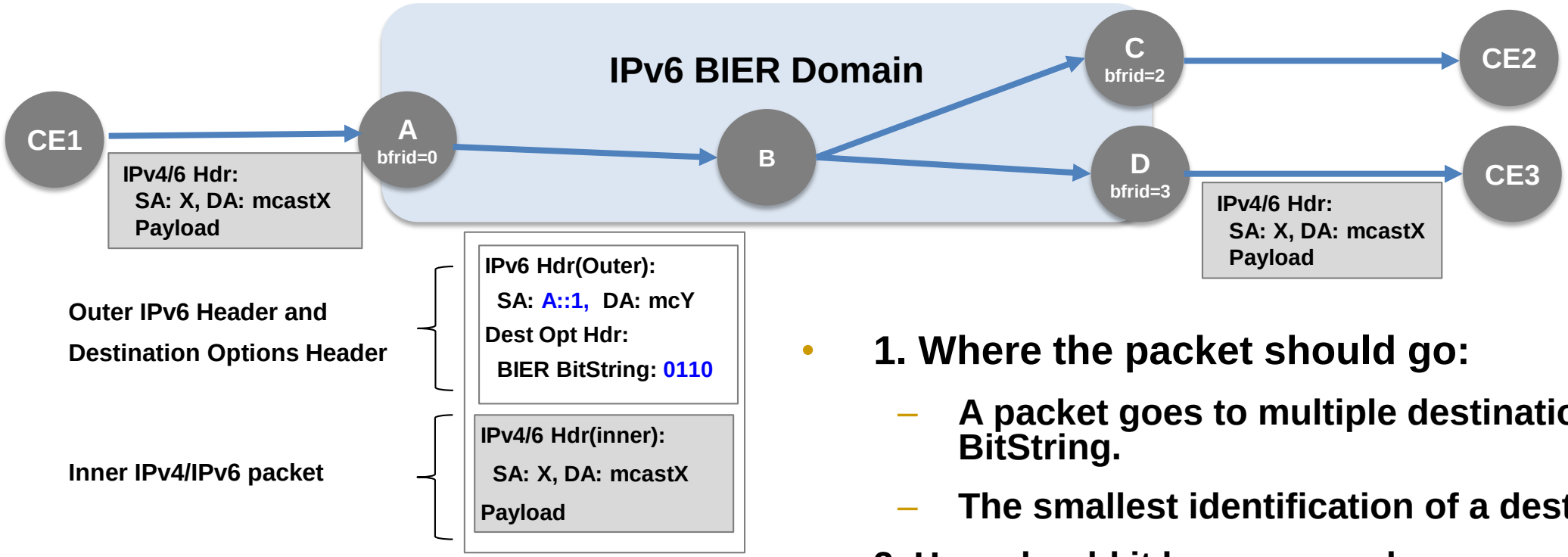
SR Multicast

- Multicast Use cases (draft-ietf-bier-use-cases-09)
  - Broadcast Video Services (eMBMS/4K)
  - IPTV and OTT Services
  - BUM in EVPN
  - Data Center Virtualization/Overlay
- Basic requirements of Multicast in SR networks
  - Control-plane simplification
  - SDN-Controlled



BIERv6: IPv6 with BIER

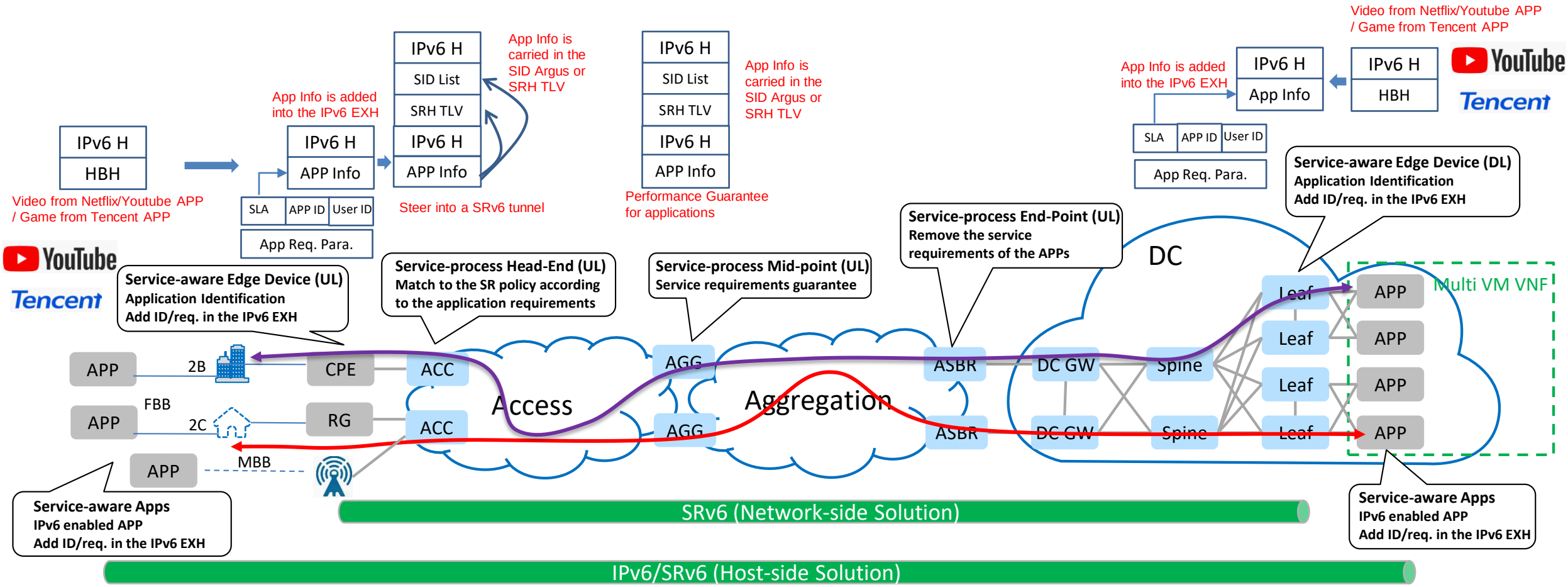


- **1. Where the packet should go:**
  - **A packet goes to multiple destinations: BIER BitString.**
  - **The smallest identification of a destination: 1 bit !**
- **2. How should it be processed:**
  - **Replicate a packet to multiple interfaces according to the BIER BitString (0110).**
  - **IPv6 SA (A::1) identify MVPN service, the same concept as IPv6 DA used for unicast.**

- draft-mcbride-bier-ipv6-requirements-00
- draft-xie-bier-ipv6-encapsulation-00
- draft-xie-bier-ipv6-mvpn-00

App-aware IPv6 Networking (APN6) Framework

- Make use of IPv6 extensions header to convey the service requirements along with the packet to the network
- To facilitate the service deployment and network resource adjustment to guarantee SLA for applications



https://tools.ietf.org/html/draft-li-6man-app-aware-ipv6-network-00 **@IETF105**

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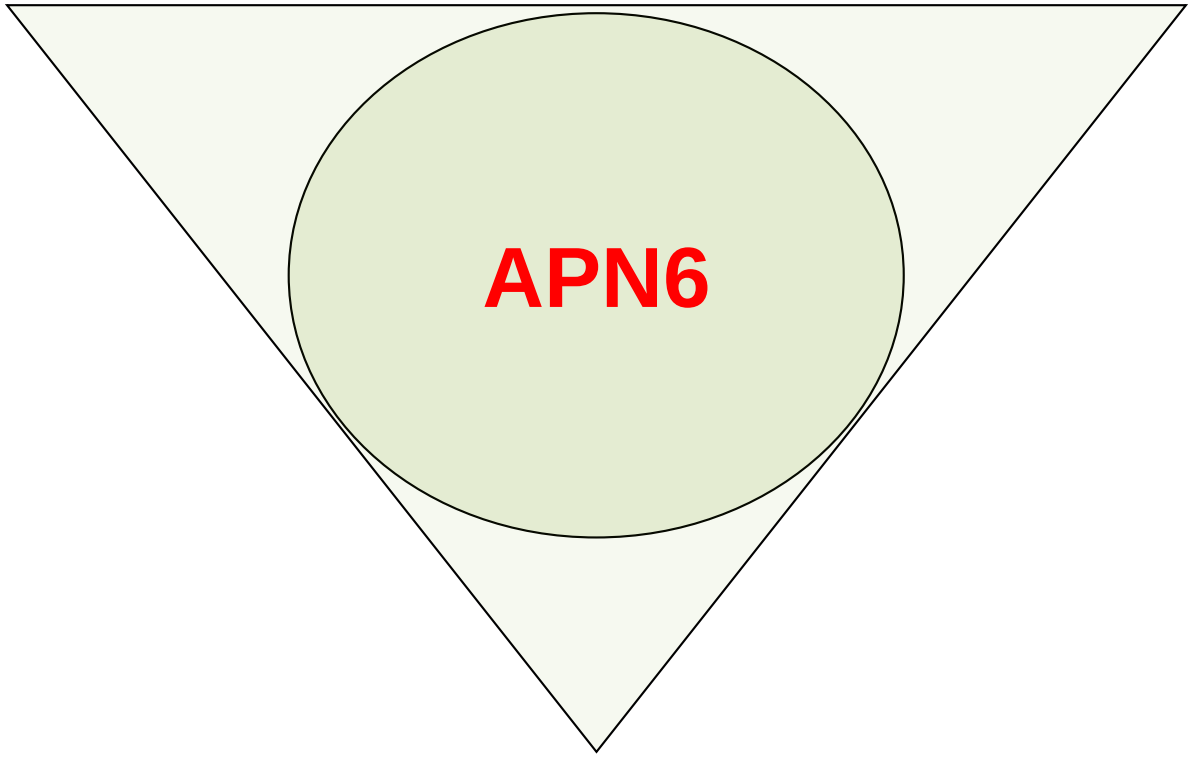
Three Elements of APN6

1. Open Application info carrying

- APP-ID
  - SLA Level
  - App ID
  - User ID
  - Flow ID
- APP Parameter Info
  - Bandwidth
  - Latency
  - Loss rate



2. Rich network services

- DiffServ
- H-QoS
- Network slicing
- DetNet
- SFC
- BIER6

3. Accurate Network Measurement

- Finer-granularity
  - per packet vs. per flow, per node vs. E2E, individual vs. statistics, etc.
- Comprehensive measurements
  - per packet with per flow, per node with E2E, individual with statistics, in-band with out-band, passive with active, etc.

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APN6 value obtained wide industry consensus

APN6 Side Meeting @ IETF105

- Thursday Morning @Notre Dame
- Attendee: 50+

Agenda

1. **Admin** (Chairs) [5 : 5/75]
2. **Problem Statement and Requirements** (Zhenbin Li) [10 : 15/75]
3. **Application-aware Information Conveying**
   a) Framework of App-aware IPv6 Networking (Shuping Peng) [10 : 25/75]
   b) Firewall and Service Tickets (Tom Herbert) [10 : 35/75]
   c) SRH Metadata for Simplified Firewall (Jim Guichard) [5 : 40/75]
4. **App-aware Services**
   a) IPv6-based DetNet (Yongqing Zhu) [5 : 45/75]
   b) SRv6 Path Segment (Fengwei Qin) [5 : 50/75]
   c) IPv6-based IFIT (In-situ Flow Information Telemetry) (Haoyu Song) [5 : 55/75]
5. **Shaping Our Discussion** (Chairs and Room) [15 : 70/75]
6. **Wrap Up** (Chairs) [5 : 75/75]

Next Step:

- Setup Mailing list to continue discussions
- https://github.com/shupingpeng/IETF105-Side-Meeting-APN6

Chinese Gov.	CAICT 中国信通院
Operators	Bell, Deutsche Telekom, SoftBank, KDDI, 中国移动 China Mobile, 中国电信 China Telecom
Vendors	Cisco, Nokia, vmware
Academia	The University of Auckland, 清華大學 Tsinghua University
OTT	Google, Tencent 腾讯
Verticals	Toyota, CERNET

Area	Topic	Draft	Vendors	Operators & Verticals
APN6	Problem statement and use cases	draft-li-apn6-problem-statement-usecases	HUAWEI	Bell, 中国电信 China Telecom, 中国移动 China Mobile, China unicom 中国联通, Toyota
	Application-aware IPv6 Networking	draft-li-apn6-app-aware-ipv6-network		

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Summary of IPv6+ Extensions

Feature	Use of IPv6 Extension Headers		
	HBH Header	Routing Header	DO Header
SRv6 TE/FRR/VPN		√	
VPN+	√	(√)	
IFIT	√	√	√
BIER			√
APN6	√	√	√

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THANK YOU