

IPv6+：面向5G和云的IP网络新时代

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

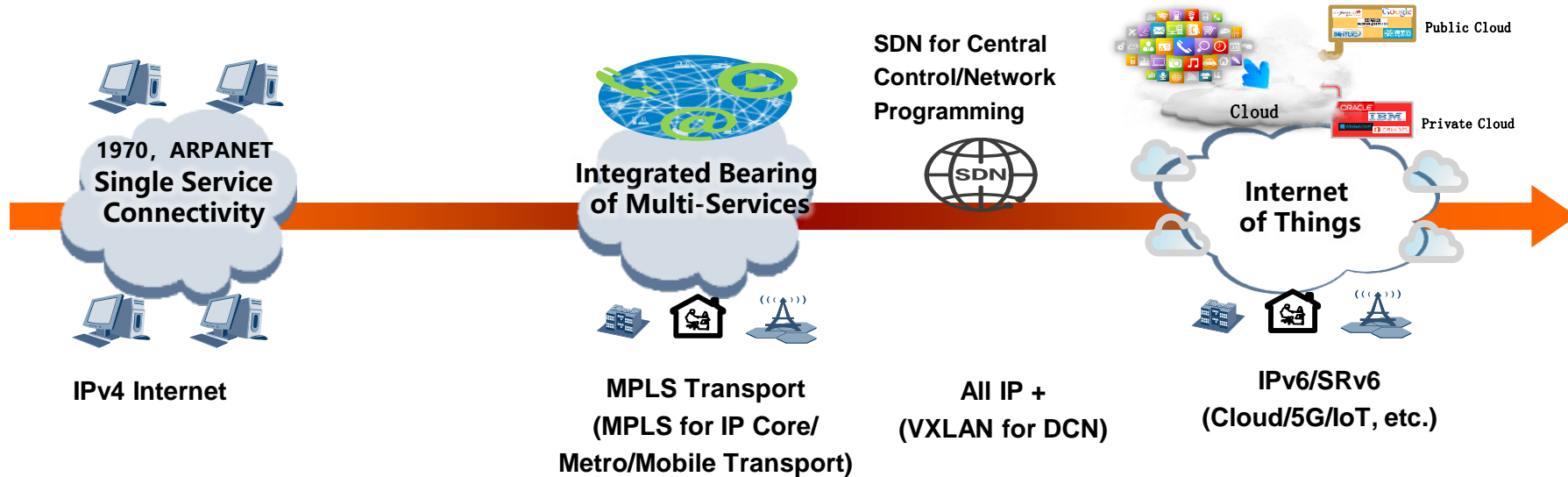
- 负责华为IP协议创新研究和标准化工作。
- 2000年加入华为，曾负责华为IP操作系统（VRP）和MPLS子系统的架构设计和开发工作。
- 2015 - 2017年担任SDN架构师，负责控制器的研究、架构设计与开发等工作。
- 自2009年起积极参与IETF标准创新工作，持续推动了SDN的BGP、PCEP、Netconf/YANG等的协议创新和标准化。当前研究的重点包括SRv6、5G承载、Telemetry、网络智能等。
- 主导和参与的IETF RFC/草案累计100余篇(www.ipv6plus.net/ZhenbinLi)，申请专利110多项。
- 2019年当选IETF互联网架构委员会（IAB）委员，承担2019 - 2021年的互联网架构管理工作。



IP技术发展历史反思

- IPv4的教训: 可扩展性 (Scalability)
- IPv6的教训: 兼容性 (Compatibility)
 - SRv6兼容IPv6转发
 - SRv6 兼容MPLS转发
- All IP 1.0的成功
 - MPLS承担了重要角色
 - SRv6必须首先继承MPLS三个成功之处: VPN/FRR/TE
- All IP1.0的挑战
 - 1. IP承载网络孤岛问题突出, 基于MPLS的网络融合复杂度高
 - 2. IPv4和MPLS封装的可编程空间有限, 无法支持新业务
 - IPv4: IPv4报头选项几乎没有实现
 - MPLS: 固定长度/固定封装域字段
 - 3. 应用与网络承载解耦导致网络自身优化难以提升价值
 - ATM到桌面: 失败
 - MPLS到云: 失败

IPv6+: 面向5G和云的IP网络新时代

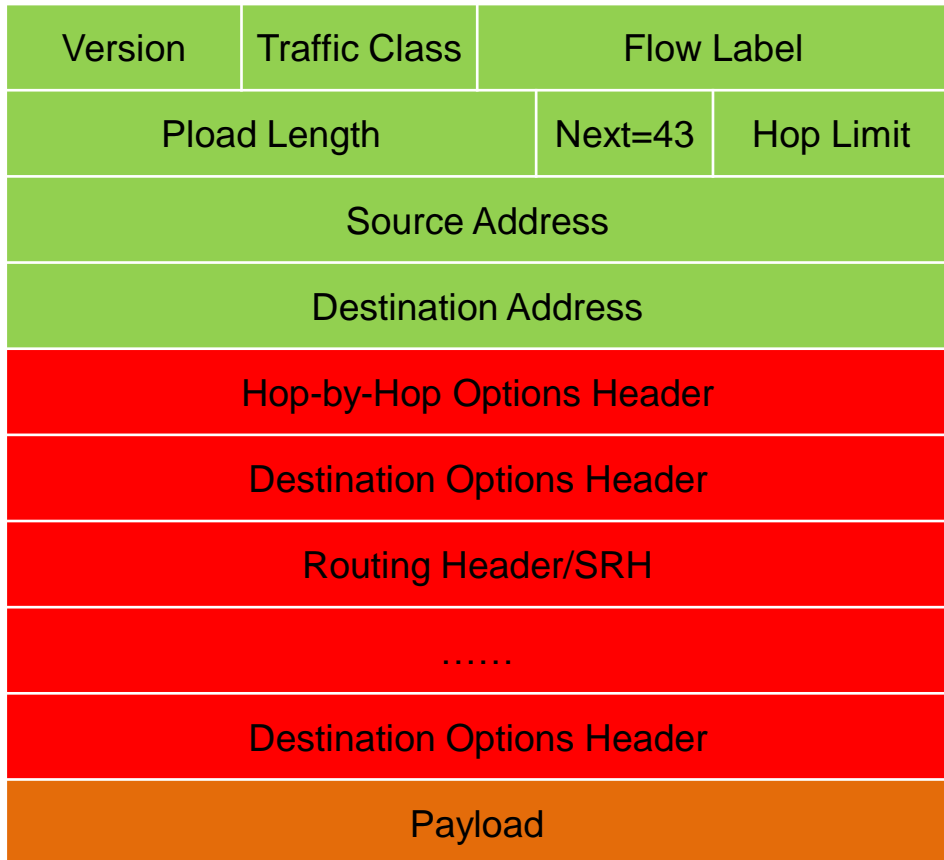


- **IPv6重思考：地址空间不足未能强烈驱动IPv6部署**
- **IPv6+ 的使命：**
 - 基于对IP可达性的亲和性，使得不同网络域间连接更容易
 - 基于IPv6扩展头/SRH等可扩展性支持更多种类的封装，满足新业务的需求。
 - 基于对IP亲和性和网络编程能力，实现IP承载网络与应用的融合，提升网络价值。
 - 结合对更多地址空间的需求，进一步推广IPv6

IPv6扩展头/SRv6: 面向未来的网络可编程能力

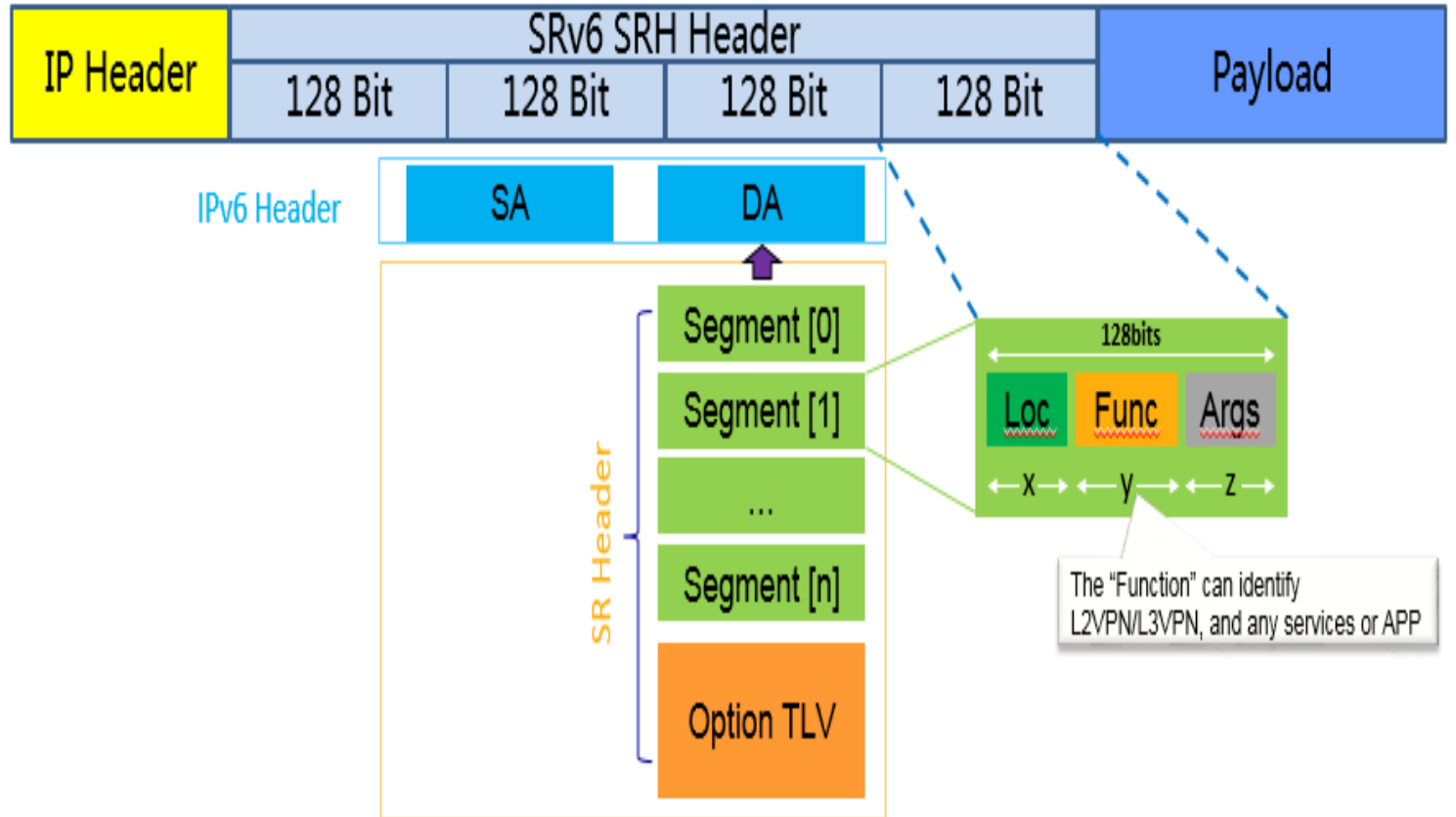
多个IPv6地址不会很占带宽么? 现在的硬件能力很强, 即使用了10个IPv6地址, 也可以做到线速转发
但是确实也存在问题, 如果payload只有8字节, 10个ipv6地址, 就很不合适
目前也有研究, 可不可以把128bit压缩到32bit

IPv6 扩展头



SRv6把128bit分成两部分loc+func
分各种segment
就像纸币, 几种面值, 然后组合起来

SRH: 三层网络可编程空间



SRv6最早是思科提出的, 华为奖其发扬光大了

IPv6+的研究与标准计划建议

IPv6+ 1.0: SRv6基础能力

- SRv6 VPN
- SRv6 TE
- SRv6 FRR

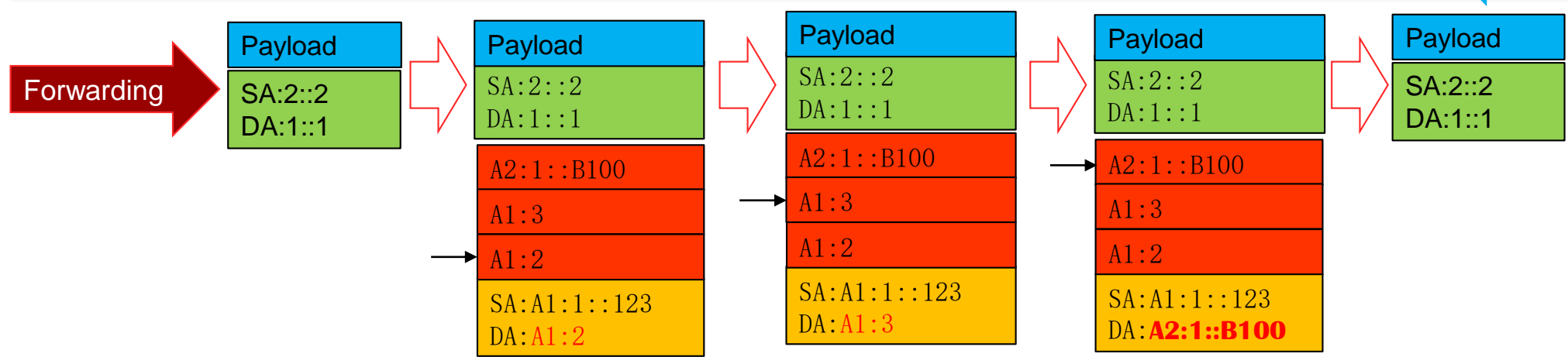
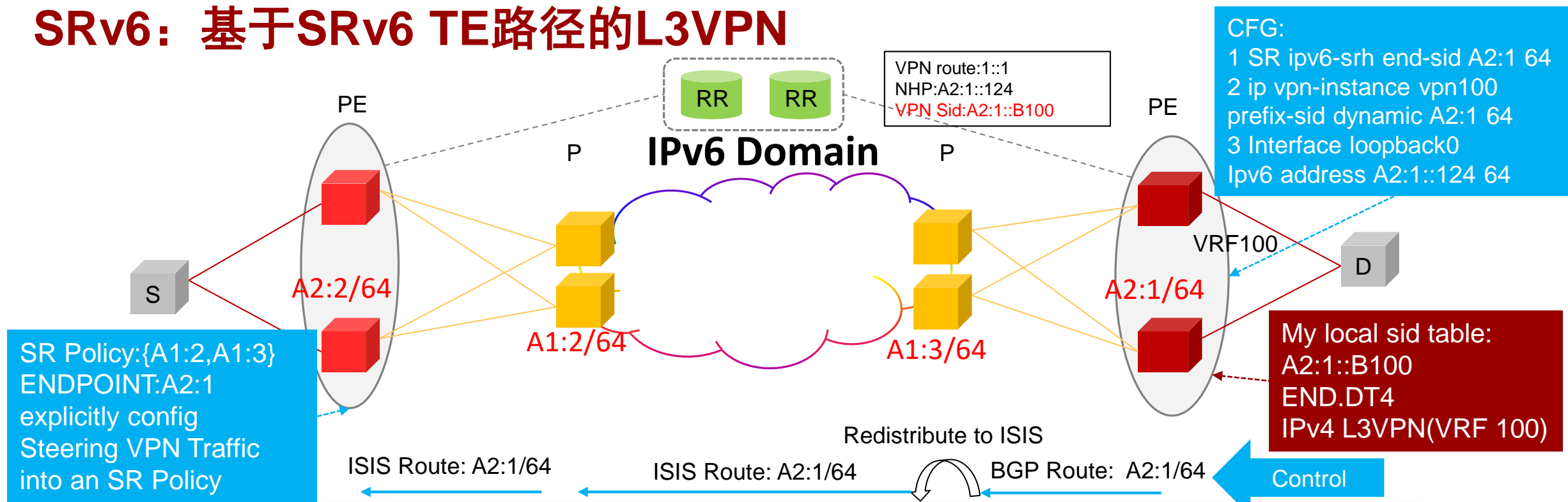
IPv6+ 2.0 : 面向5G/云的新兴网络服务

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

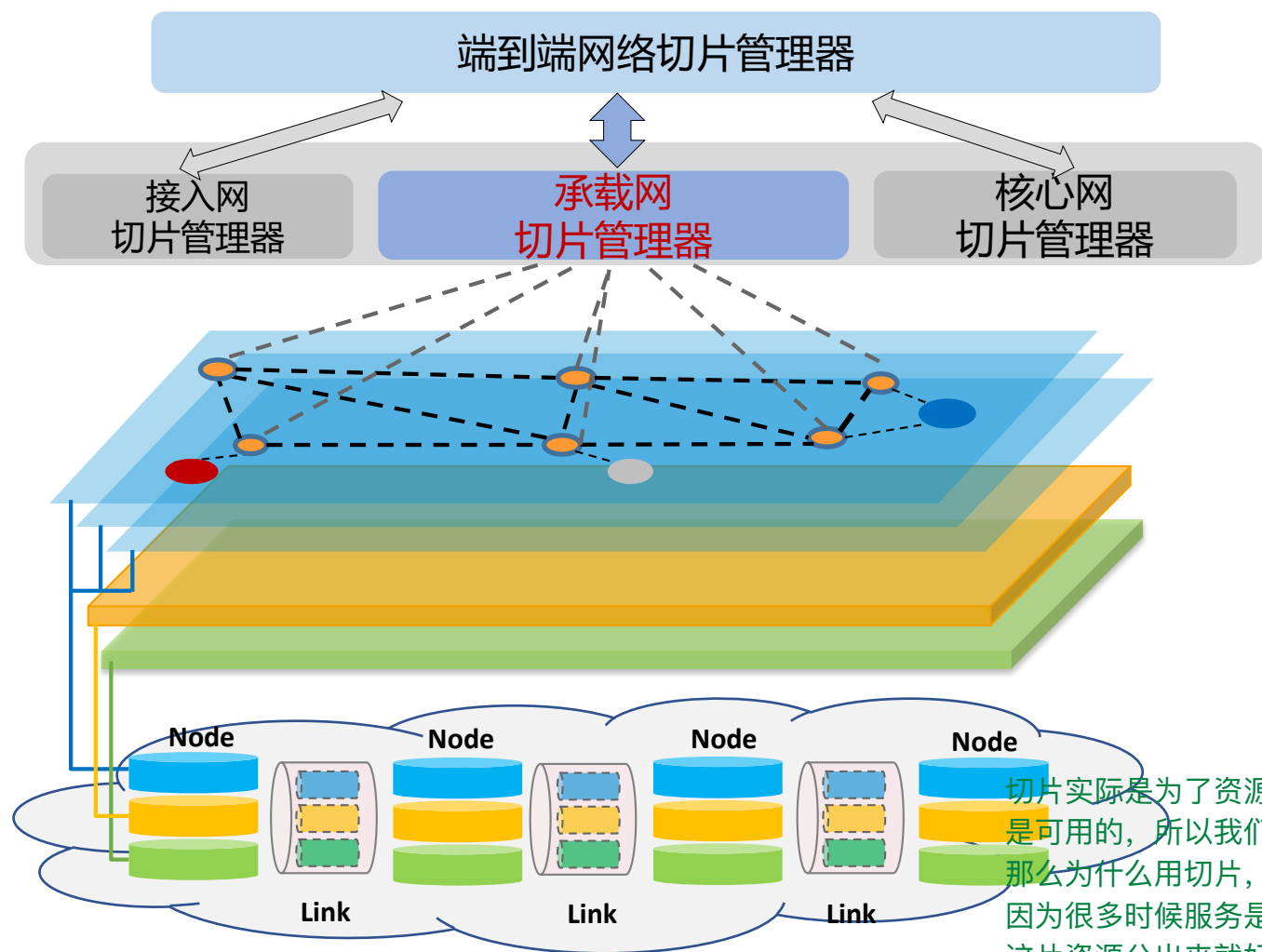
IPv6+ 3.0: 应用感知的IPv6网络 (APN6)

- 转发面: 通过IPv6扩展头传递应用信息
- 控制面: 通过控制协议交互应用信息

SRv6: 基于SRv6 TE路径的L3VPN



VPN+ 承载网切片架构



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
based

物理网络资源切分

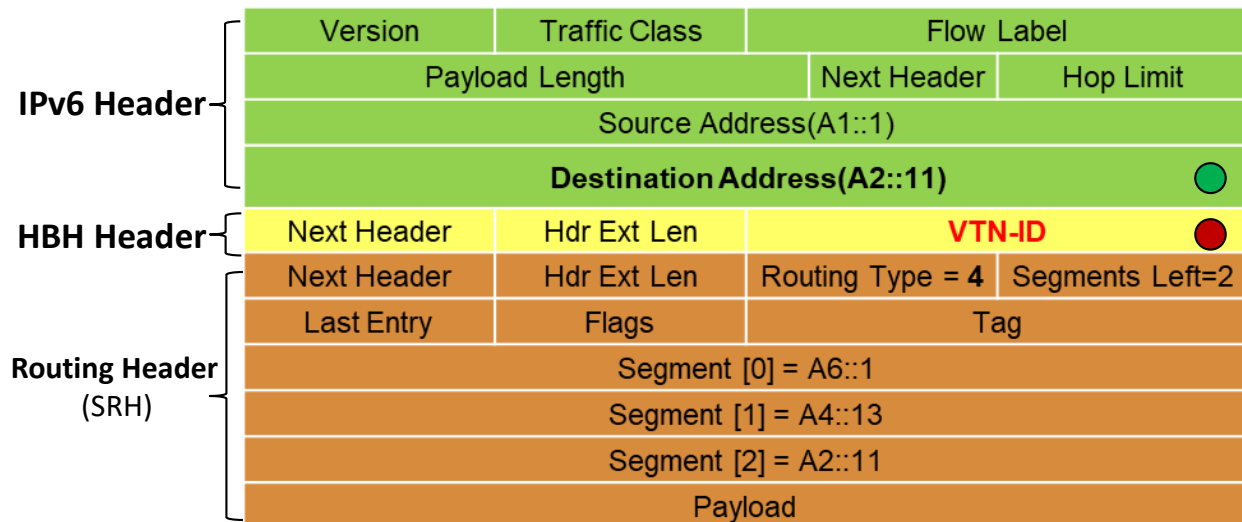
切片实际是为了资源专用, 比如远程手术, 对资源的要求很高, 要求可以保证这段资源一定是可用的, 所以我们对网络资源进行切片, 资源的隔离越来越硬

- 物理接口
- 逻辑子接口 (FlexE, 信道化子接口)
- 独立转发队列
- TSN

因为很多时候服务是多点到多点的, 如果是虚通道, 通道的量会很大, 切片的方式, 只要把这片资源分出来就好了, 实际到具体某一个片里, 还是best effort, 只是可以实现比如华为和腾讯的业务互不干扰

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

基于IPv6数据面扩展支持网络切片标识

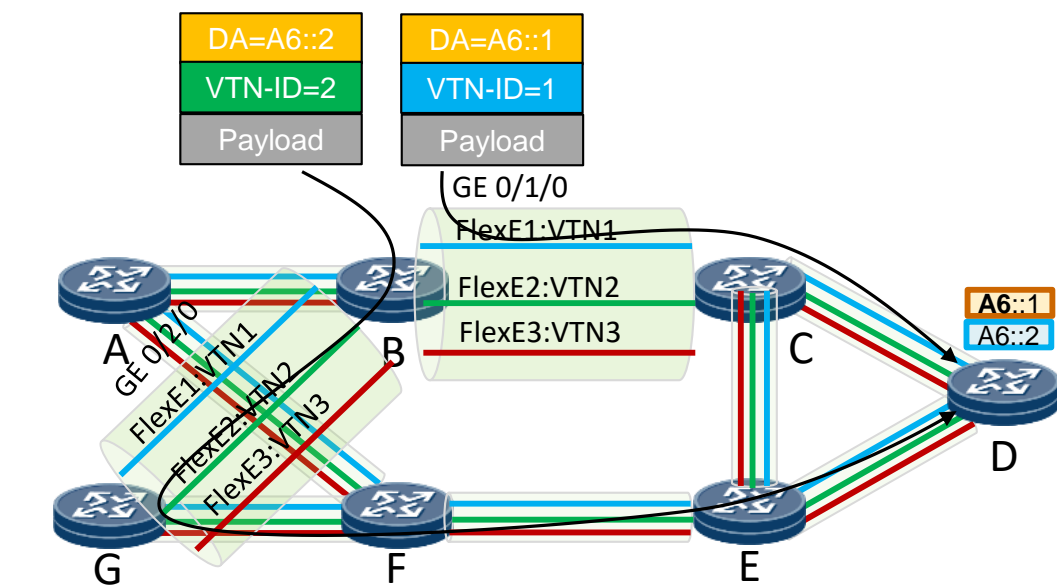


- 数据面使用两种转发标识的组合标识流量的二维转发需求(拓扑、资源)，指导切片报文转发

- 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

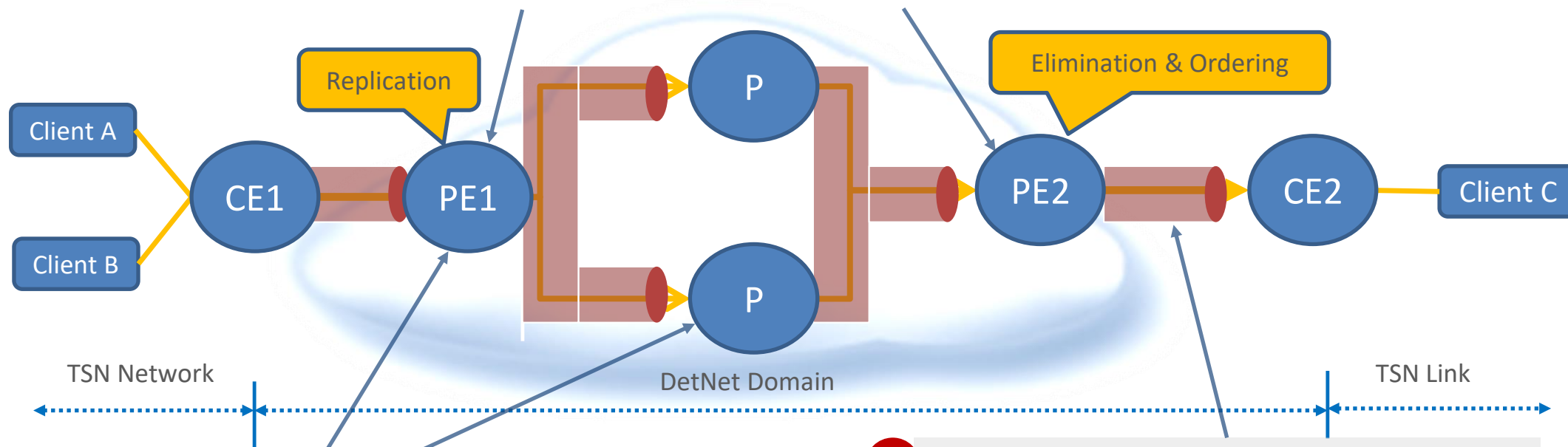
确定性网络核心技术

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

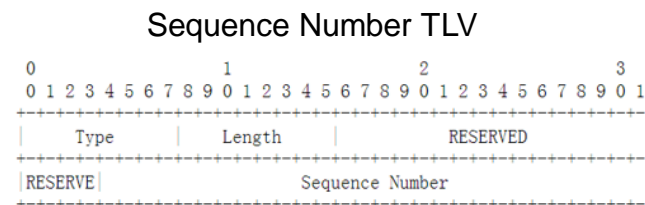
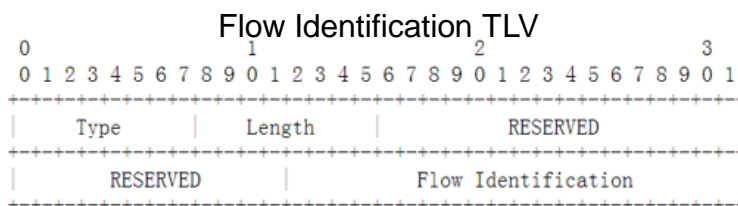
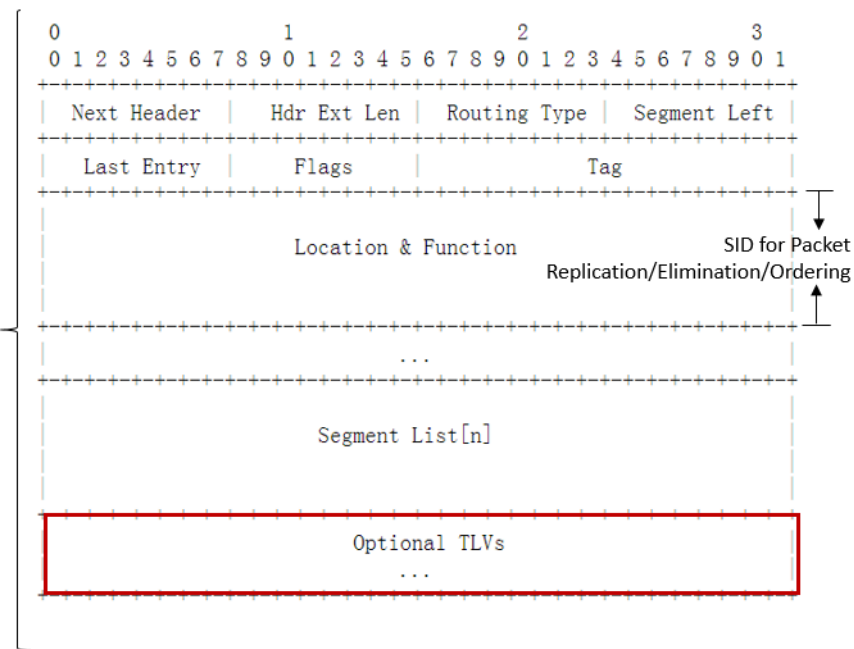
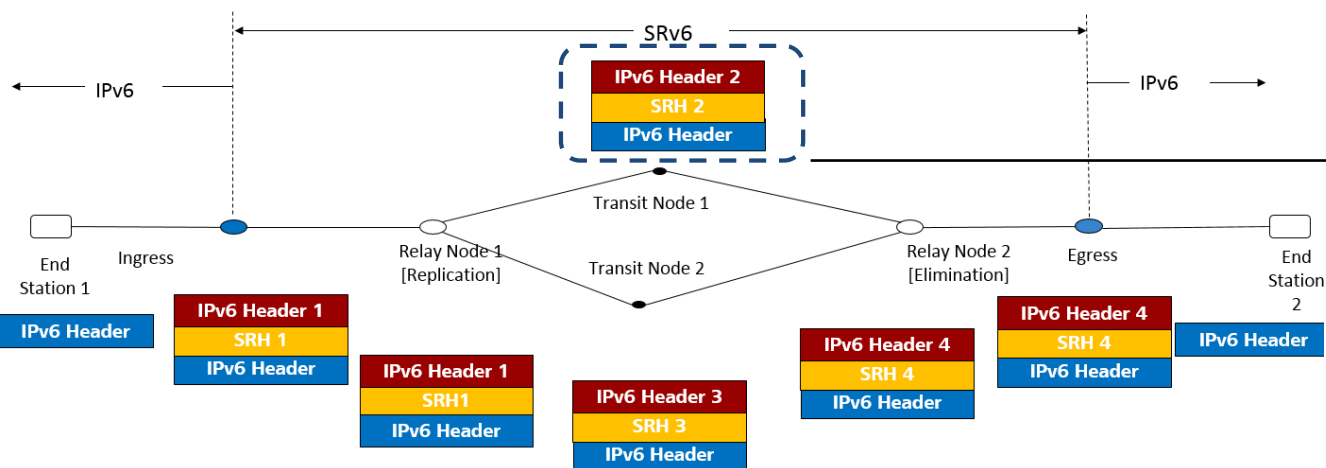
指定DetNet流量的传输路径，以控制端到端时延

- Segment Routing

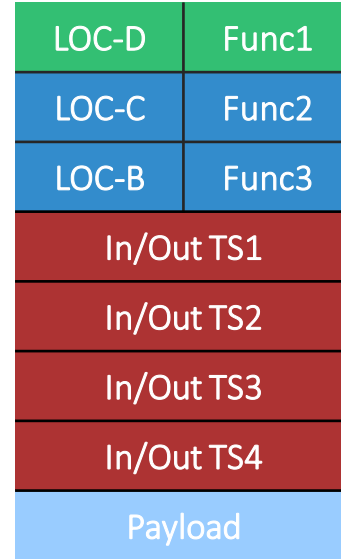
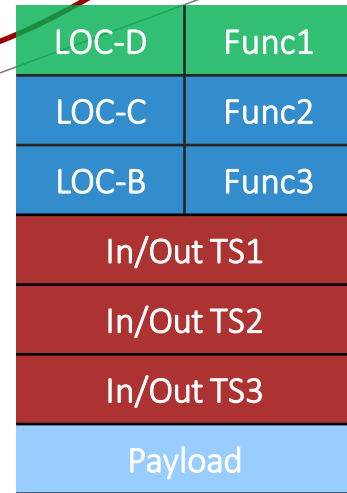
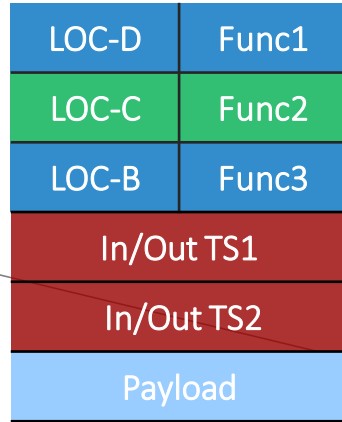
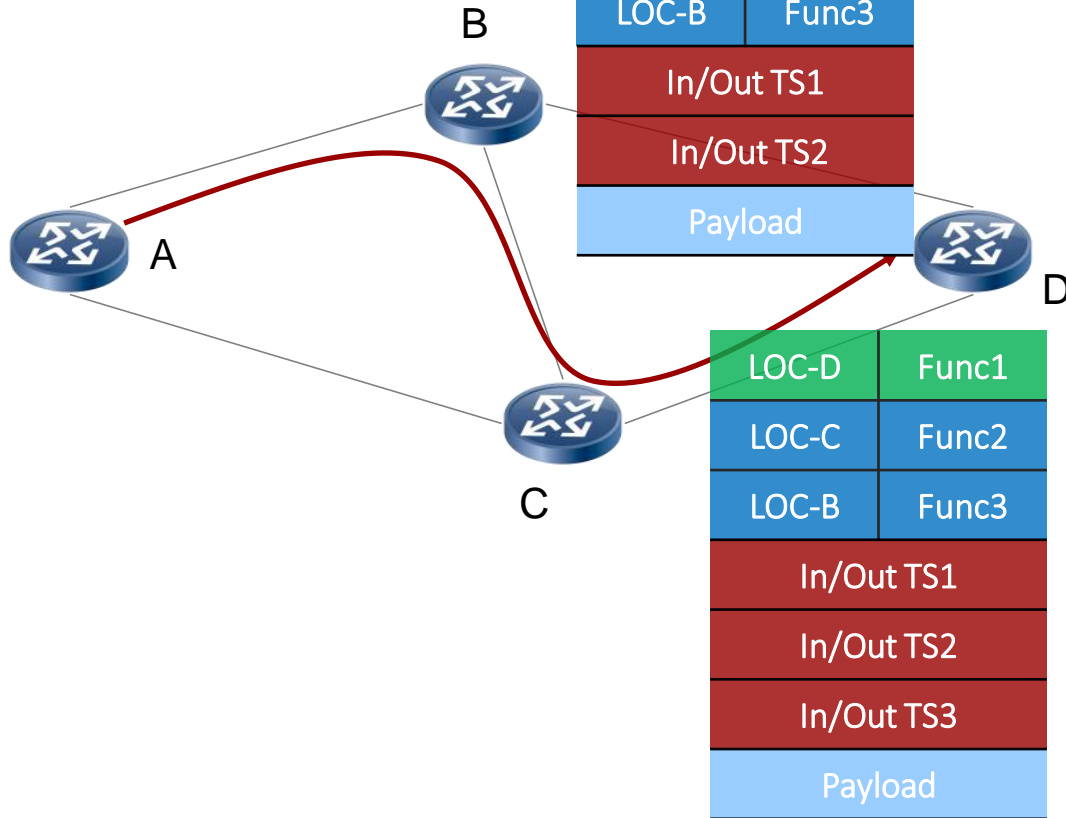
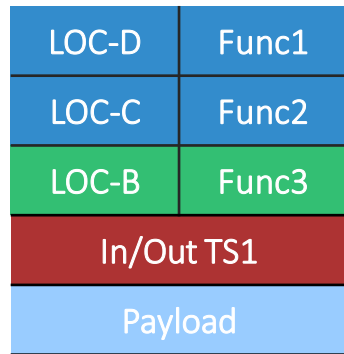
基于SRv6的冗余传输解决方案

SRv6 零丢包解决方案:

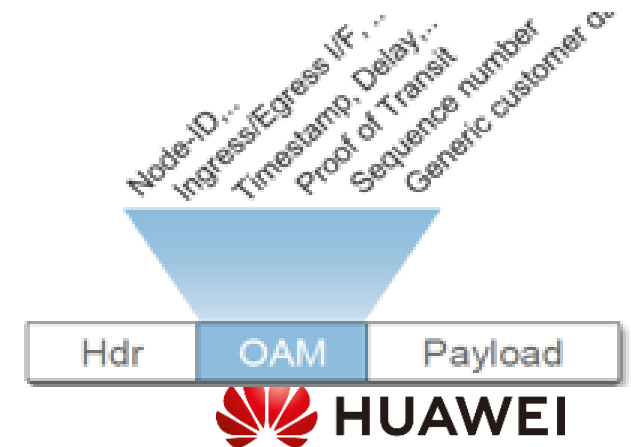
- ✓ 不耦合的显示路径: 用segment list指示复制报文沿着两条或以上不重合的路径进行转发;
- ✓ SRv6扩展: 在SRH中optional TLV中指示流标识(Flow Identification)和报文的序列号(Sequence Number), 用于实现多路径的选收;
- ✓ 利用SRv6的灵活编程能力: 定义新的SRv6 Function, 指示报文在指定节点进行报文复制和汇聚;



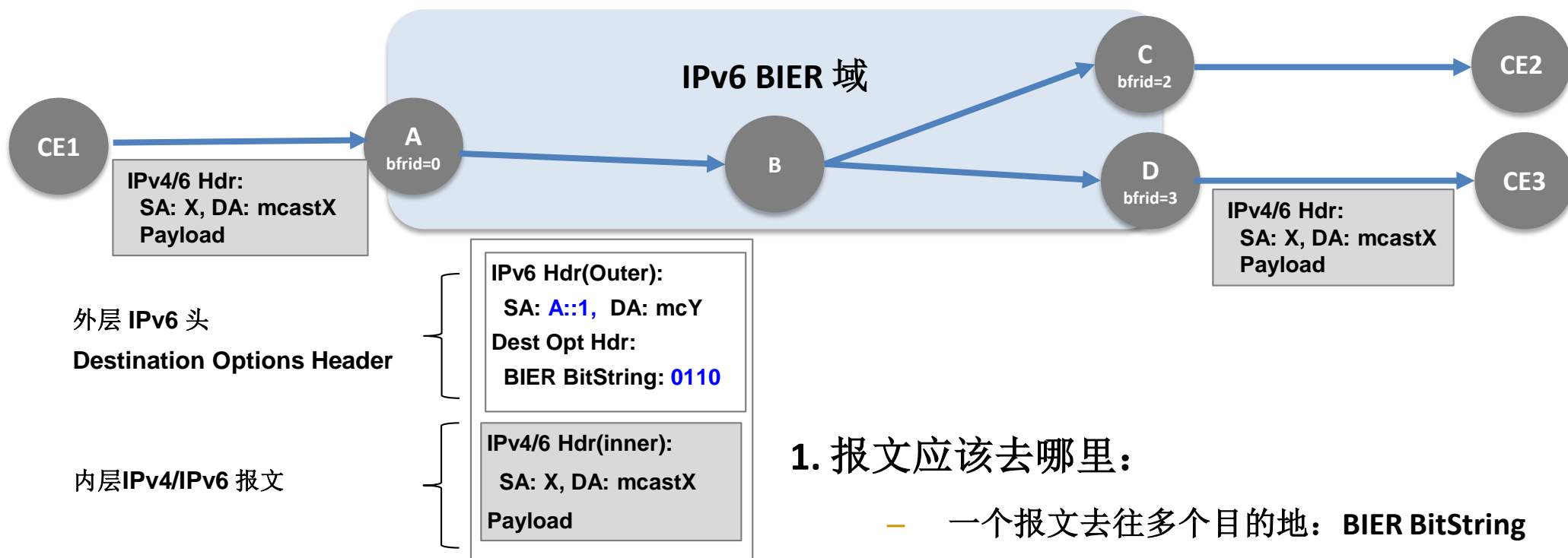
SRv6/IPv6 IFIT (In-situ Flow Info Telemetry) : 更有效的数据面监控机制



- IFIT (In-situ Flow Information Telemetry)架构文稿: [draft-song-opsawg-ifit-framework](#)
- SRv6 In-situ OAM文稿: [draft-ali-6man-spring-srv6-oam-01](#)
- IPv6 IFIT/IOAM文稿: [draft-li-6man-ipv6-sfc-ifit-00](#) IETF104@Prague



BIERv6: 新型无状态组播



外层 IPv6 头

Destination Options Header

内层 IPv4/IPv6 报文

1. 报文应该去哪里:

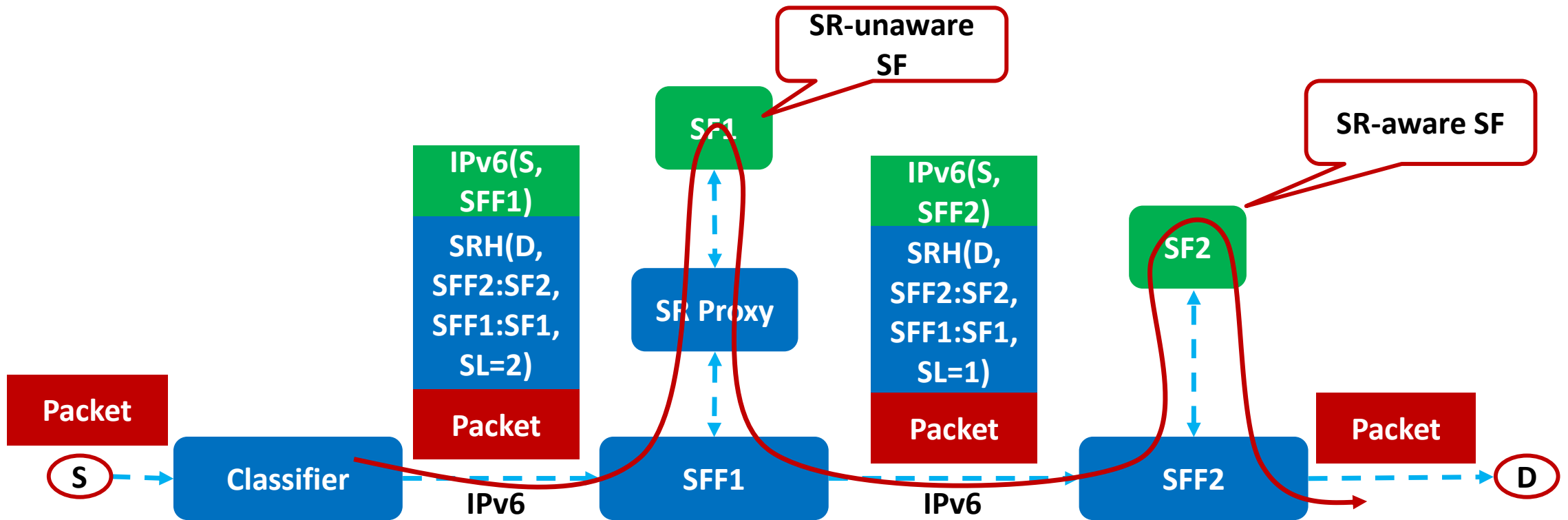
- 一个报文去往多个目的地: **BIER BitString**
- 一个目的地的最小标识: **1 bit!**

2. 应该怎样处理:

- 根据 **BIER BitString (0110)** 将一个数据包复制到多个接口
- **IPv6 SA (A::1)** 标识 MVPN 业务, 与 IPv6 DA 用作 unicast 概念相同

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

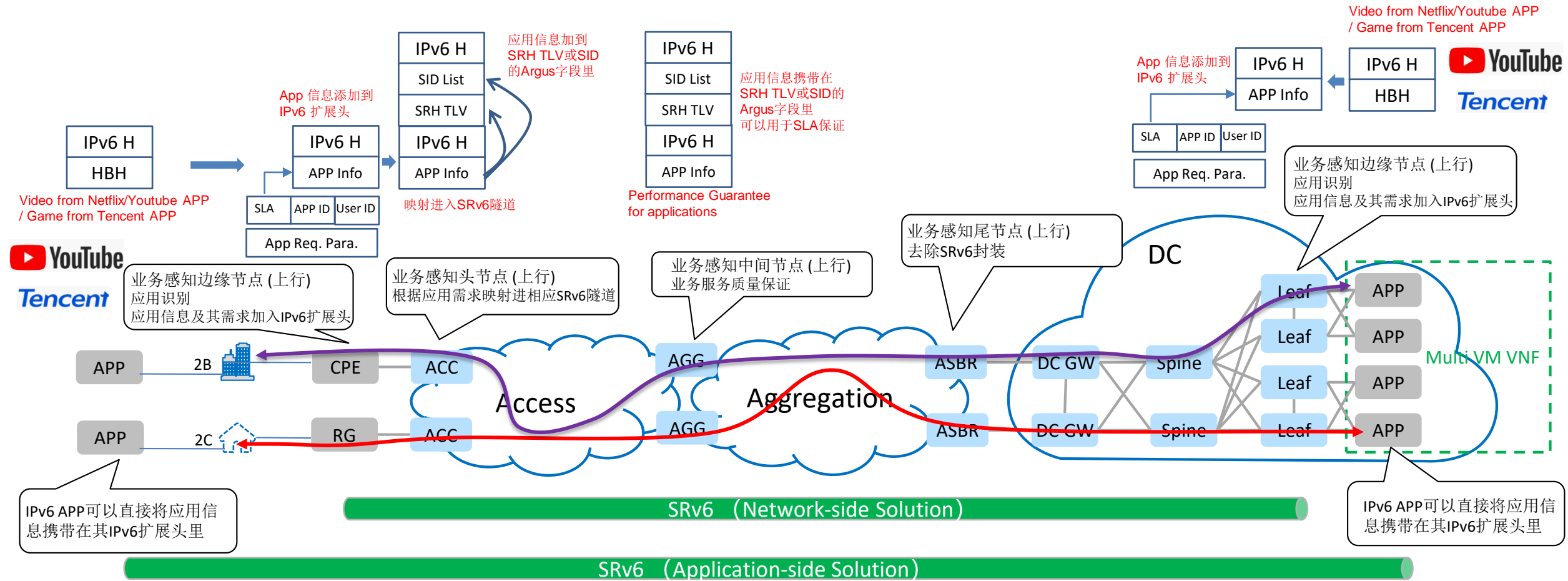
基于SRv6的无状态SFC：更简单灵活的SFC方案



- ❑ 由华为、思科共同主导的 [draft-xuclad-spring-sr-service-programming](#) 提出
- ❑ 纯SRv6 SFC方案，业务链的转发信息由SRH中的SID List编码，仅需发布Service SID信息即可
- ❑ SID指示数据包的转发路径和业务信息
- ❑ 无需再SFF上维持Per-path的状态信息
- ❑ SRH TLV可携带Metadata，可完全替代NSH

应用感知的 (Application-aware) IPv6网络

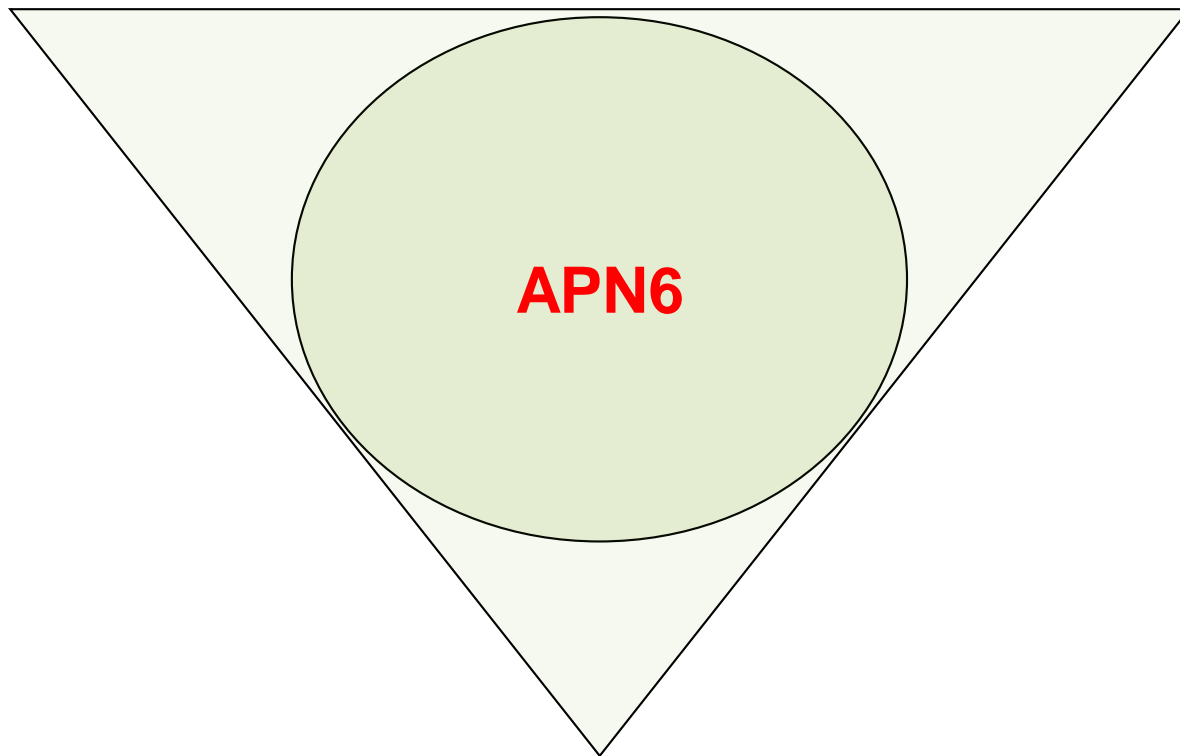
- 利用IPv6扩展头将应用信息及其需求传递给网络
- 根据携带应用信息，通过业务的部署和资源调整来保证应用的SLA要求



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.)

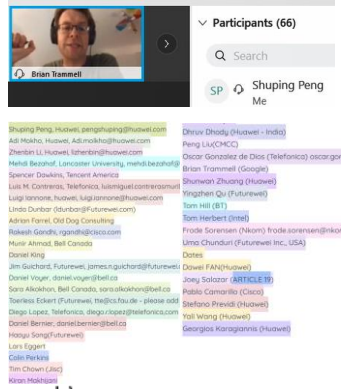
APN6的价值获得广泛的产业共识

APN6 first presented @ IETF104
APN6 Side Meeting @ IETF105 & 108

- Attendee: 50+(105) & 60+(108)

Tentative Agenda

- Introduction & Agenda Bashing (5 mins)
- Attempts in IETF History (15 mins)
 - What attempts (SPUD and PLUS BoEs)? What lessons learned?
- Requirements on Application-awareness in Networks (20 mins, 5 mins each)
 - Operators present their use cases to make clear that they have the Requirements on Application-awareness
 - Bell Canada – Service/Application aware
 - Telefonica – CDN
 - China Mobile – MEC
 - China Unicom – Game Acceleration
- APN Framework (5 mins)
 - Introduce APN Framework and the available Demo, Hackathon, INFOCOM, etc.
- Acquisition, Encapsulation and Conveying of Application-related Information (30 mins)
 - Network Tokens
 - FAST
 - APN6
- Discussions & Clarifications – Collecting views from the IETF community (10 mins)
 - Whether it will bring privacy issue? If yes, how to overcome?
 - Whether it will bring security issue? If yes, how to overcome?
- Conclusion – the way forward (5 mins)



Next Step

- APN BoF @IETF

APN Application-aware Networking
apn-2020@ho...

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People

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APN6-INFOCOM
APN6 may be demonstrated in INFOCOM
v0 0 0 0 Updated 14 days ago

IETF-APN-Email-List
v0 0 0 0 Updated 14 days ago

IETF108-Side-Meeting-APN
The APN Side Meeting Agenda @IETF108
v2 0 0 0 Updated 16 days ago

IETF108-RTGWG-APN
Introduces the latest updates of APN, clarifies the scope of APN, and lists the scenarios that do not have the privacy and security issues
v0 0 0 0 Updated on 30 Jul

IETF108-Hackathon-APN
Forked from Laralright/IETF108-Hackathon-APN
v1 0 0 0 Updated on 28 Jul

APN6-Introduction
This flash introduces the APN6 concept.
v0 0 0 0 Updated on 30 Jun

APN6-Demo
Demonstration of some key features of APN6
v0 0 0 0 Updated on 30 Jun

APN6-Interop2020
APN6 in - English in - Italian - Tel...

<https://github.com/APN-Community>

Demo Abstract: APN6: Application-aware IPv6 Networking

Happy Peng, Gang Chen, Jianhua Gu, Jianhua Li, Guangwen Sheng, Department of Computer Science, Tsinghua University, Beijing, China, penghappy@tsinghua.edu.cn

Abstract—This Demo abstracts the Application-aware IPv6 Networking (APN6) framework, which is able to make the distributed and challenge of the above-mentioned traditional application awareness mechanisms. In this Demo, we demonstrated a demo that includes all the key components in the APN6 framework and their capabilities. According to the application characteristic information carried in the IPv6/IPv4 packets, the application flows are mapped into corresponding IPv6/TCP tunnels. Utilizing the multi-rate network performance monitoring and measurement enabled by Intelligent Flow Information Technology (IFIT) [1], we further extending it to make it application-aware in this setup, we showed that the VNF application's flow can be automatically adjusted away from the path with degrading performance to the one that has good quality. Furthermore, the flexible application-aware VNF offloading application-aware Value Added Service (VAS) together with the network-side features is also demonstrated.

Keywords—IPv6, IETF, Segment Routing, IPv6, SDN

I. INTRODUCTION

The network operators have been facing the challenges of providing better services to their customers. Nowadays, it becomes more challenging, as 5G and industry vertical networks, the over-congested core services with diverse but demanding requirements such as low latency & high reliability are accessing to the network. Application-aware network is the promising, low-latency, and video-conferencing have highly demanding requirements on the network performance. Meanwhile, they are the actual scenario-producing applications. The existence of network operators have to have differentiated SLA guarantees for their various demanding core services. However, the current network operators are still not aware of which applications the traffic traversing their network actually belong to. Therefore, the network enhancement of the network operators gradually becomes large but dumb pipes. Accordingly, the network operators are losing their opportunities of making some business in the 5G era and beyond.

There are already some traditional ways to make the network aware of the applications in certain scenarios. However, they all have some drawbacks: 1) Flow Tables are widely used for the traffic matching, with Access Control List (ACL) and Policy Based Routing (PBR), but still not enough information for supporting the fine-grained service provision, and can only provide indirect application information which needs to be further translated in order to indicate a specific application; 2) Deep Packet Inspection (DPI) can be used to extract more application-specific information by deeply inspecting the packets, but since CAPSIC and GREK will be introduced as well as security challenges; 3) Classification and SDN-based solutions is used in the case of SDN, with the SDN controller being aware of the service requirements of the applications on the network through the interface with the controllers and the service requirements used by the controller for traffic



II. APPLICATION-AWARE IPv6 NETWORKING

IPv6/IPv4 has some programmable space in their encapsulation, the IPv6 extension header such as Hop-by-Hop Options Header (HOPO), Destination Options Header (DOH) [2], and Segment Routing Header (SRH) [3] which is a new type of Routing Header (suggested earlier [4]) currently being standardized in IETF. SRH itself also has some programmable space, e.g. the top field, the segment field of each Segment ID (SID), and the SID Type Length Value (TLV) [5]. These programmable space can be used to carry application characteristic information into the network and make the network aware of applications as well as their requirements. Accordingly, the network is able to steer the application flows into corresponding IPv6/TCP tunnels or paths to guarantee its SLA as set-up-a-priori. This is the essential idea of APN6. The application characteristic information includes application ID which identifies application, the user of application, and the SLA level, i.e. to indicate the packets as part of the traffic flow belonging to a specific Application-Class/SLA level. It could also include network performance measurement information, specifying at least one of the following parameters: bandwidth, delay, loss rate, etc.

III. DEMONSTRATION

The APN6 Demo setup is shown in Fig. 2. In this Demo, we demonstrated the APN6 framework as well as its key components as shown in Fig. 1 and described in Section II. The key capabilities of the network-side components are shown, that is, the application characteristic information is not encapsulated by the APN6 but by the Application Edge.

As shown in Fig. 2, two applications (VLC and FTP) attached to the Source are generating IPv6 traffic, with the help

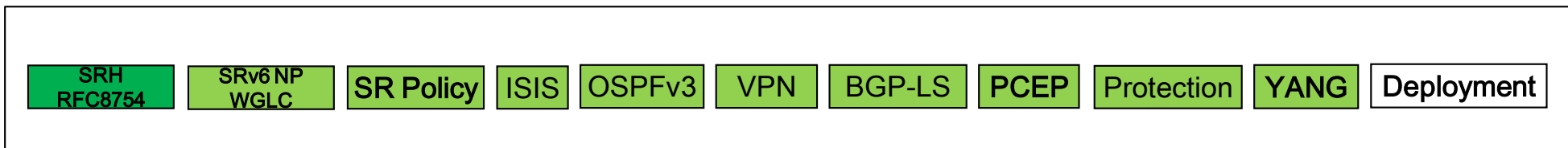


IPv6+扩展头总结

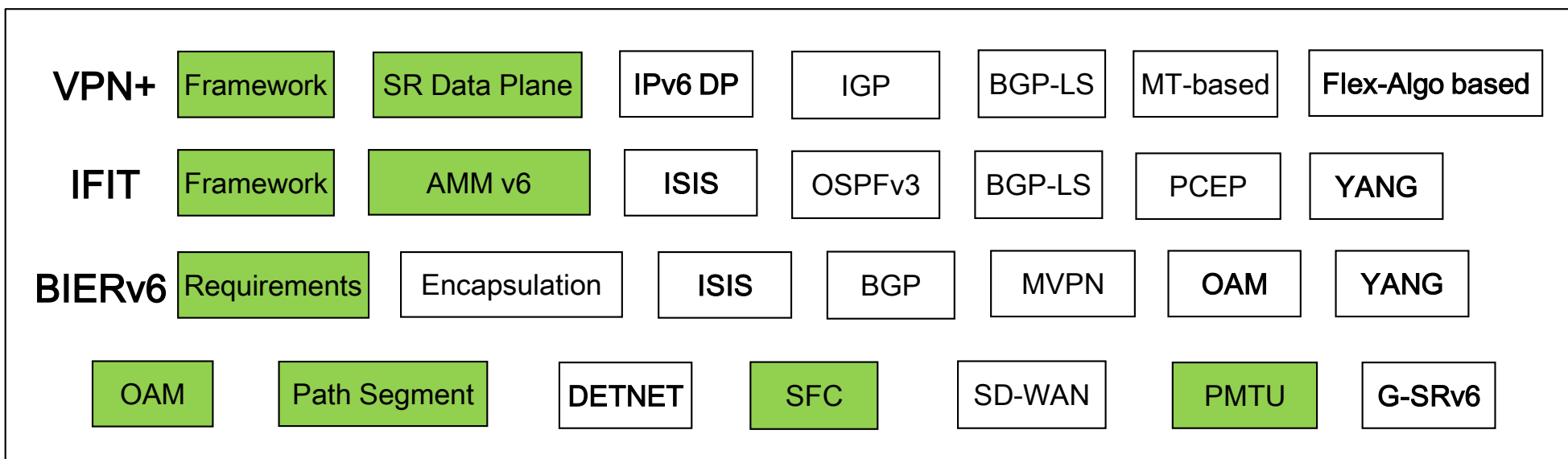
特性	IPv6扩展头		
	HBH Header	Routing Header	DO Header
SRv6 TE/FRR/VPN		√	
VPN+	√	(√)	
IFIT	√	√	√
BIER			√
APN6	√	√	√

IPv6+标准整体布局与进展

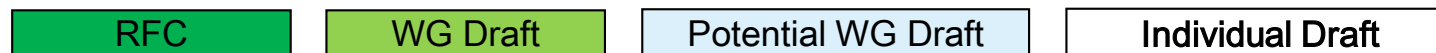
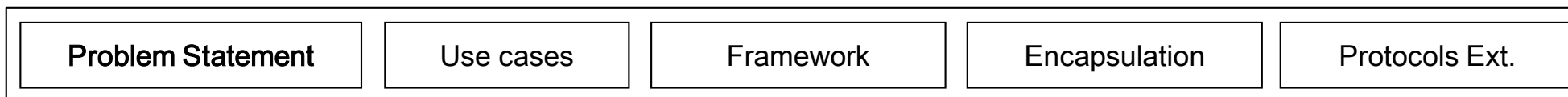
IPv6+ 1.0
SRv6



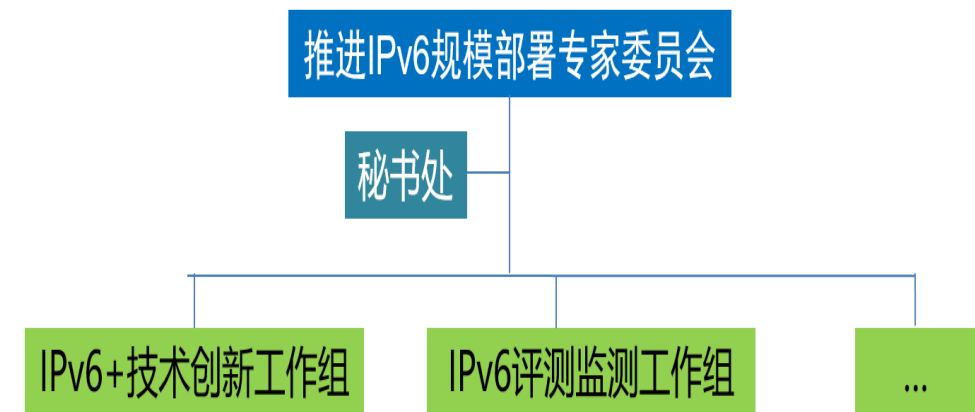
IPv6+ 2.0
5G&Cloud



IPv6+ 3.0
APN6



IPv6 + 产业活动



产学研用，多维融合

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/>



SRv6新书发布



Thank you.

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