

IPv6+和感知应用的网络 (APN)

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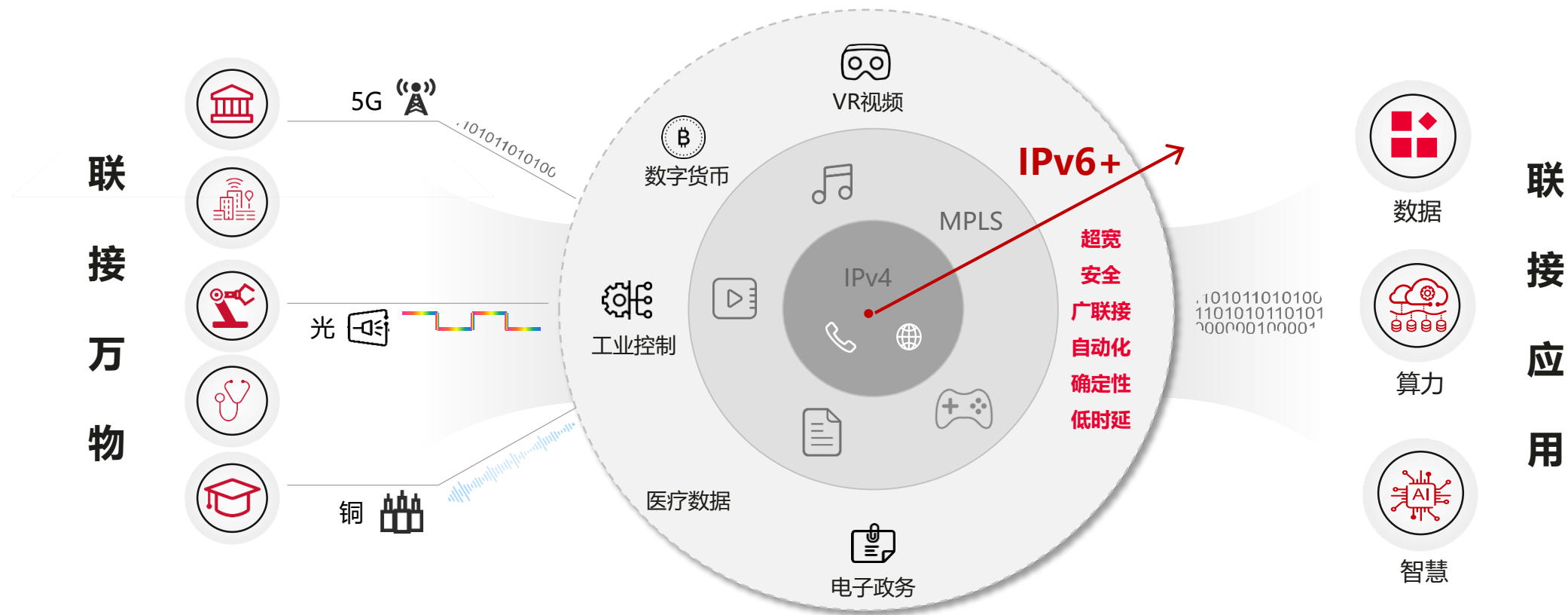
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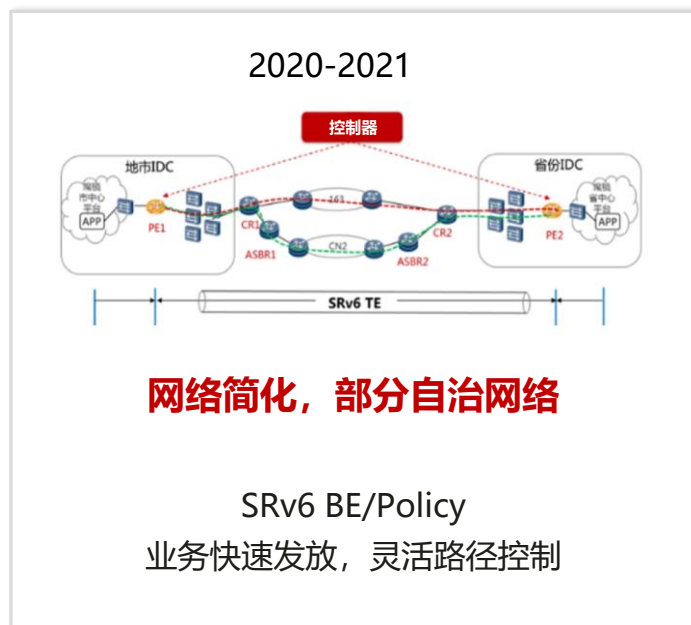
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- 感知应用的网络（APN）
- 感知算力的网络（CAN）
- 总结

数据通信产业迈向IPv6+ 智能联接时代



IPv6+ 技术持续演进，不断提升业务体验保障能力

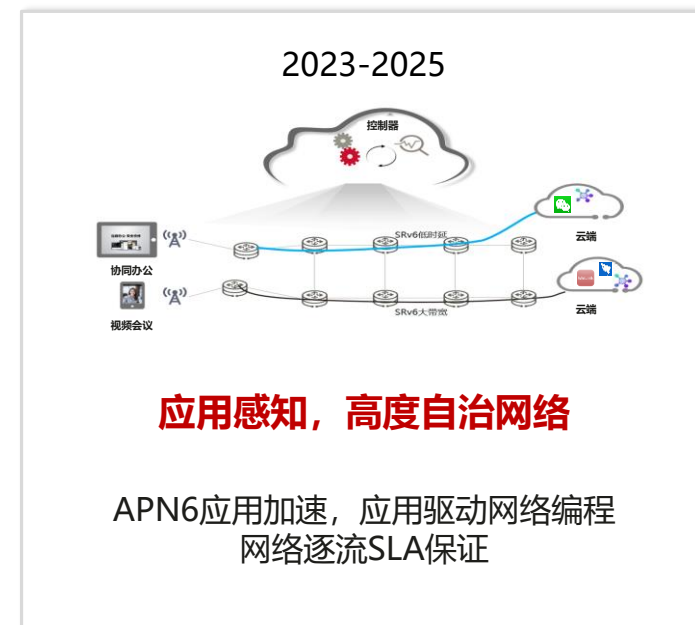
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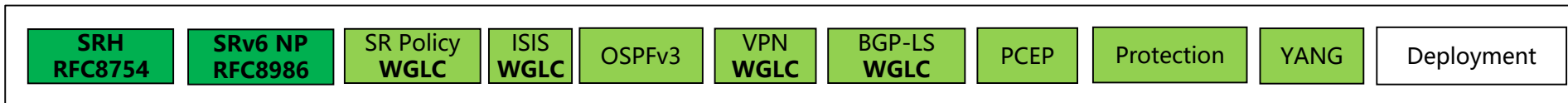


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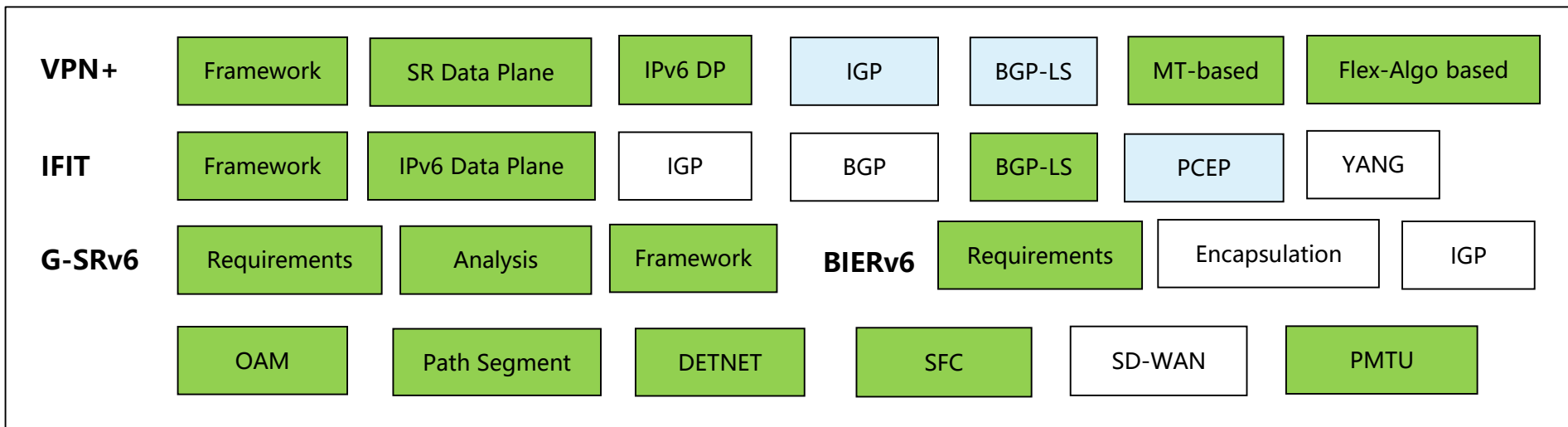


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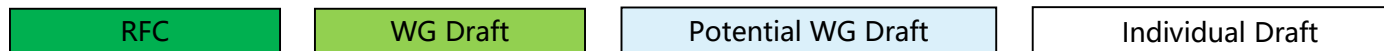
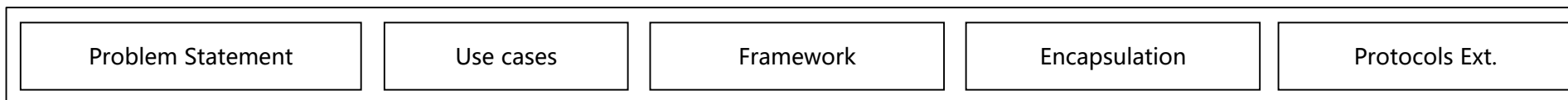
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IPv6 Enhanced 2.0 5G&Cloud



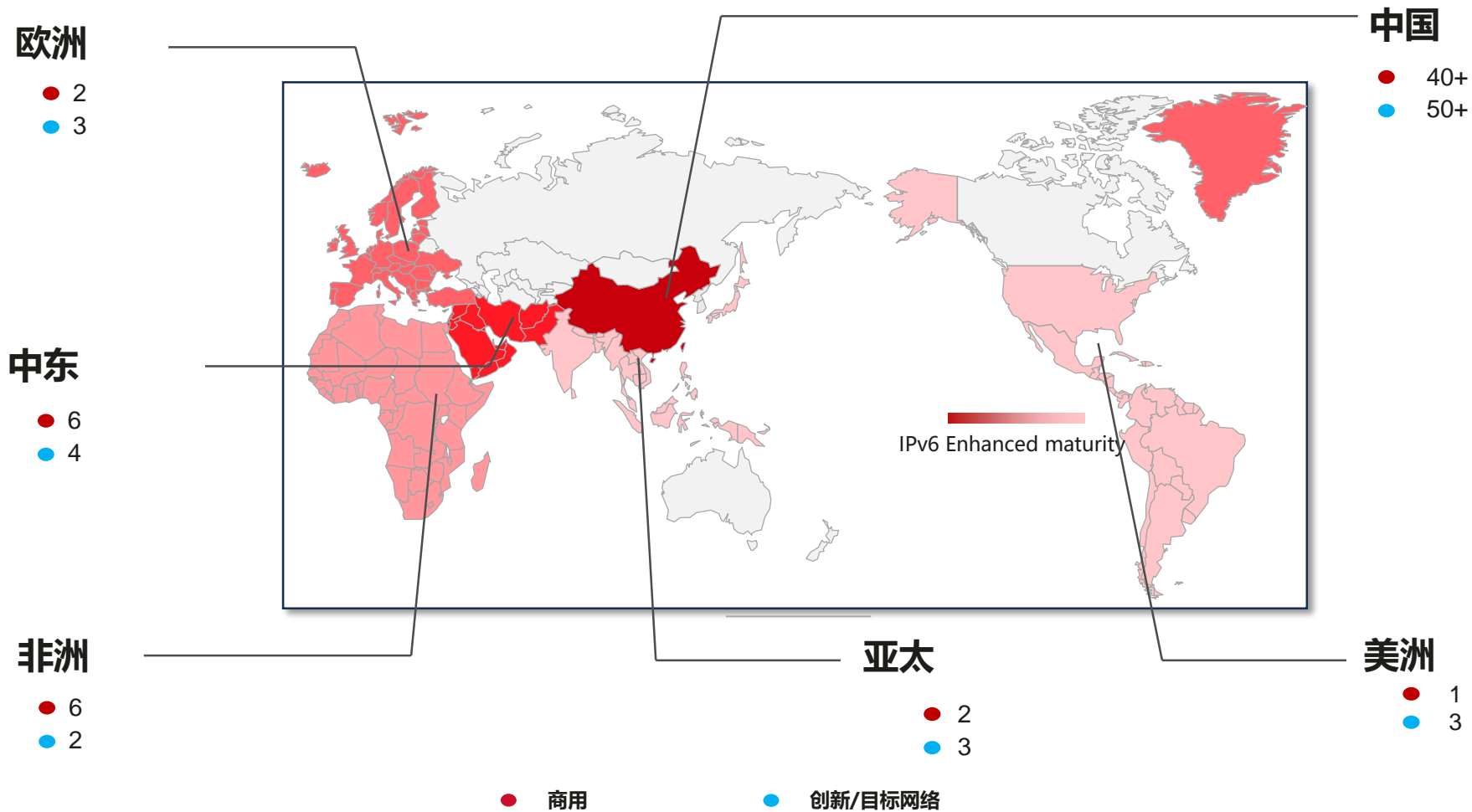
IPv6 Enhanced 3.0 APN6



www.ipv6plus.net 提供更多标准进展信息

IPv6+ 在全球的快速部署和应用

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云网协同向算网一体演进

阶段一：泛在协同

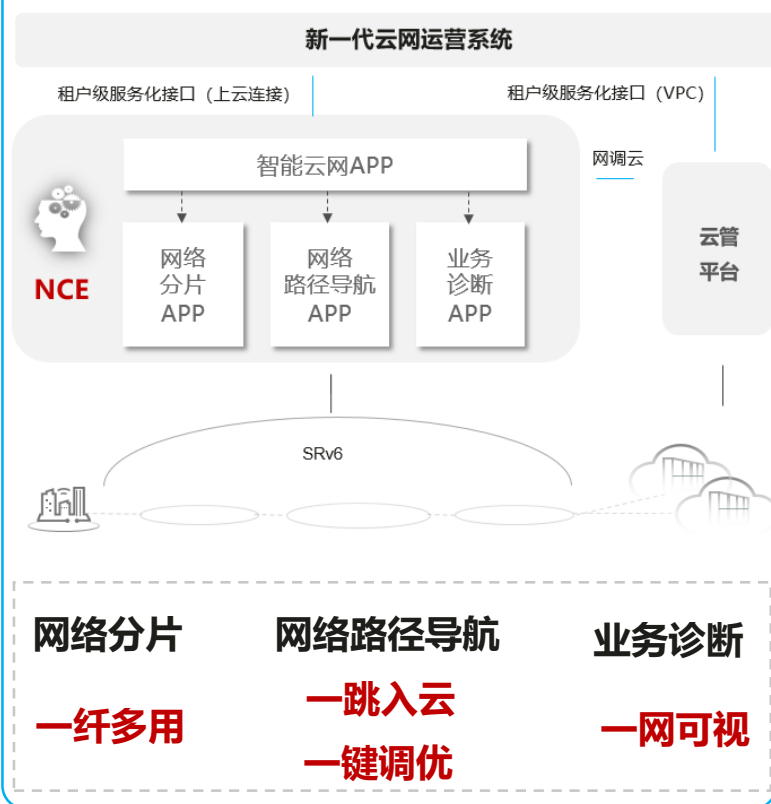


阶段二：融合统一



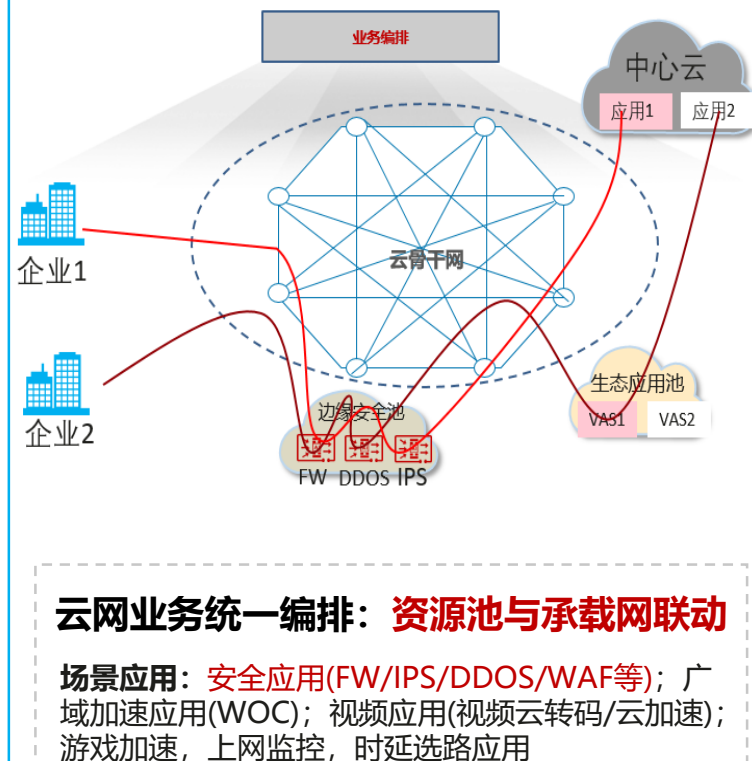
阶段三：一体内生

云网管控拉通，聚焦网络编程



- 关键技术：SDN、SRv6/G-SRv6、网络切片、业务级感知（随流检测）、400G

云网业务统一编排

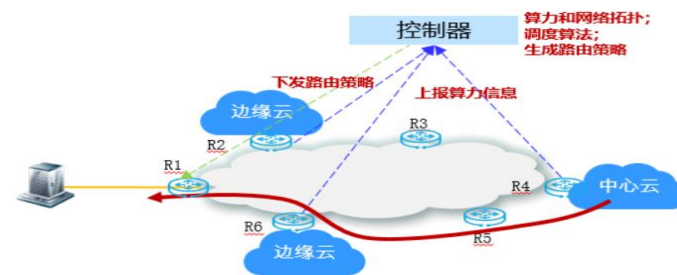


- 关键技术：确定性网络、应用感知、业务链

算力+网络统一调度（探索）

集中式方案

节点上报算力，基于控制器进行调度



分布式方案 (CAN)

路由协议扩散算力，分布式节点进行调度



- 关键技术：算力路由、在网计算等

目录

- IPv6+与算力网络
- **感知应用的网络（APN）**
- 感知算力的网络（CAN）
- 总结

APN6背景 (1) IP网络业务面临的挑战

当前运营商承载网发展四大瓶颈问题

瓶颈一：管道化

- **扩容不增收**：带宽需求高速增长，从网络服务的收益有限
- **资源利用率低**：网络无法获得细粒度的应用信息，只能通过轻载满足

瓶颈二：网络边际效应递减

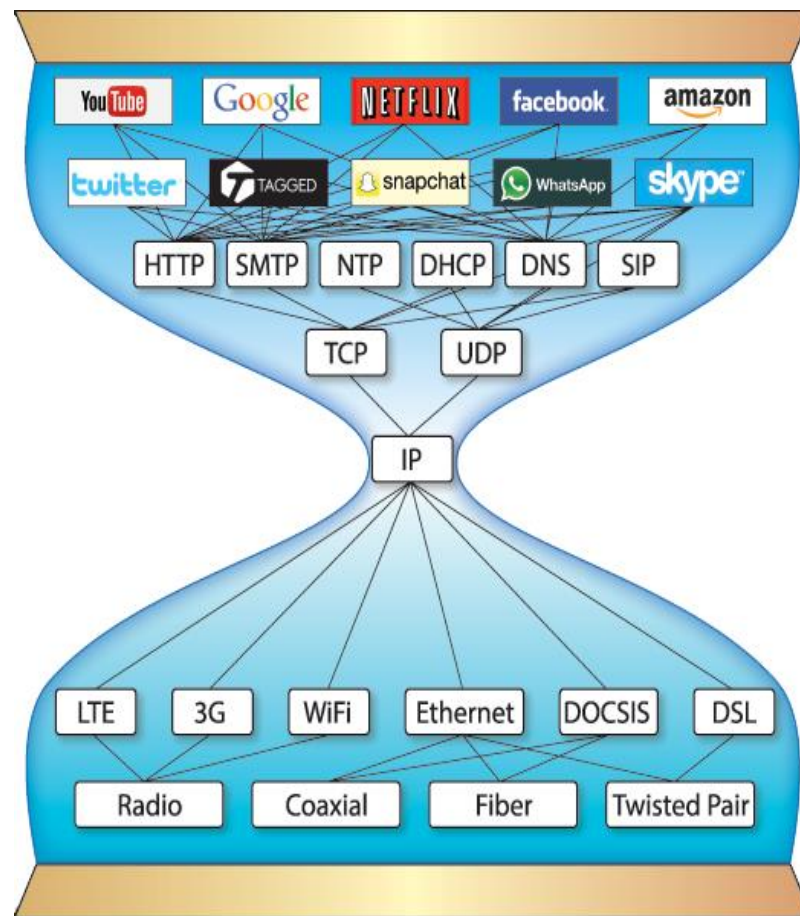
- 关键服务**重复开发**导致边际效应递减
 - 基于MPLS的VPN/TE/FRR
 - 基于SR-MPLS的VPN/TE/FRR
 - 基于SRv6的VPN/TE/FRR

瓶颈三：网络能力发挥局限

- **网络差异化服务能力大幅提升**：
 - 网络服务能力更加丰富：DiffServ/HQoS/SR Policy/网络切片/随路检测/SFC
 - 网络服务可扩展性极大提升：海量TE连接；海量切片；
- **缺乏灵活细粒度标识映射网络服务**

瓶颈四：加密流

- **应用加密**导致导致网络精细化服务更加困难
 - QUIC加密导致MiddleBox失效
 - 为了保证安全和隐私，ISOC提倡端到端加密



B5G-6G/云网算网/物联网等新兴业务持续发展会出现越来越多新应用，网络需要应用协同，灵活发挥细粒度服务能力

APN6背景 (2) 传统精细化服务存在的挑战和需求

AS IS: 提供细粒度服务的传统方法

传统方法面临的挑战

五元组	使用通过 $\{srcIP, dstIP, srcPort, dstPort, protocol\}$ 五元组标识业务流 (ACL/PBR)	<ul style="list-style-type: none">• 粒度: 只能提供间接的应用信息• 性能: 为保证转发性能, 需要昂贵的硬件资源, 规格受限• 隐私: 原始数据报文被封装在隧道中后难以获取五元组信息
DPI	深入读取IP报文应用层信息解析内容识别应用	<ul style="list-style-type: none">• 性能: 需要深入应用层, 会带来转发性能问题• 隐私: 安全和隐私问题挑战很大
应用-网络 控制器协同	应用通过业务控制器与网络的协同器/控制器联动	<ul style="list-style-type: none">• 复杂度: 方案协作关系复杂, 为关键应用提供差异化服务周期长• 标准化: 涉及系统间调用诸多接口标准化和互操作性挑战

TO BE: 应用与网络融合提供精细化服务的需求逐渐成为一个重要的发展趋势

- 通过引入应用的标识和参数实现到网络服务的映射, 释放网络差异化服务的能力。
- 新的应用标识需要解决传统方法面临的挑战, 降低精细化服务的CAPEX和OPEX。
- 应用和网络都支持IP, 这意味着IP可以在应用和网络融合中充当重要的媒介。

APN6的三要素

开放的应用信息携带

- APP-ID
 - 应用ID
 - 用户ID
- APP参数信息
 - 带宽
 - 时延
 - 丢包率

丰富的网络服务

- DiffServ
- H-QoS
- SR Policy
- 网络切片
- DetNet
- SFC
- BIER6



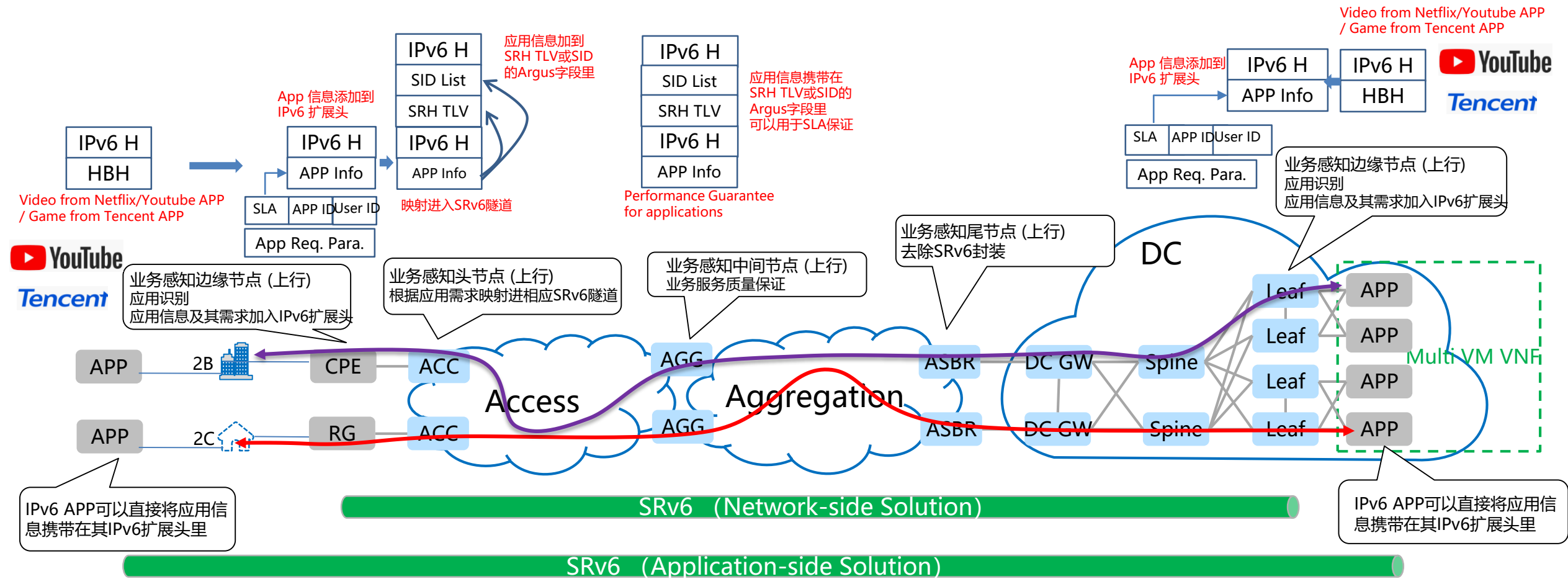
APN6

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.)

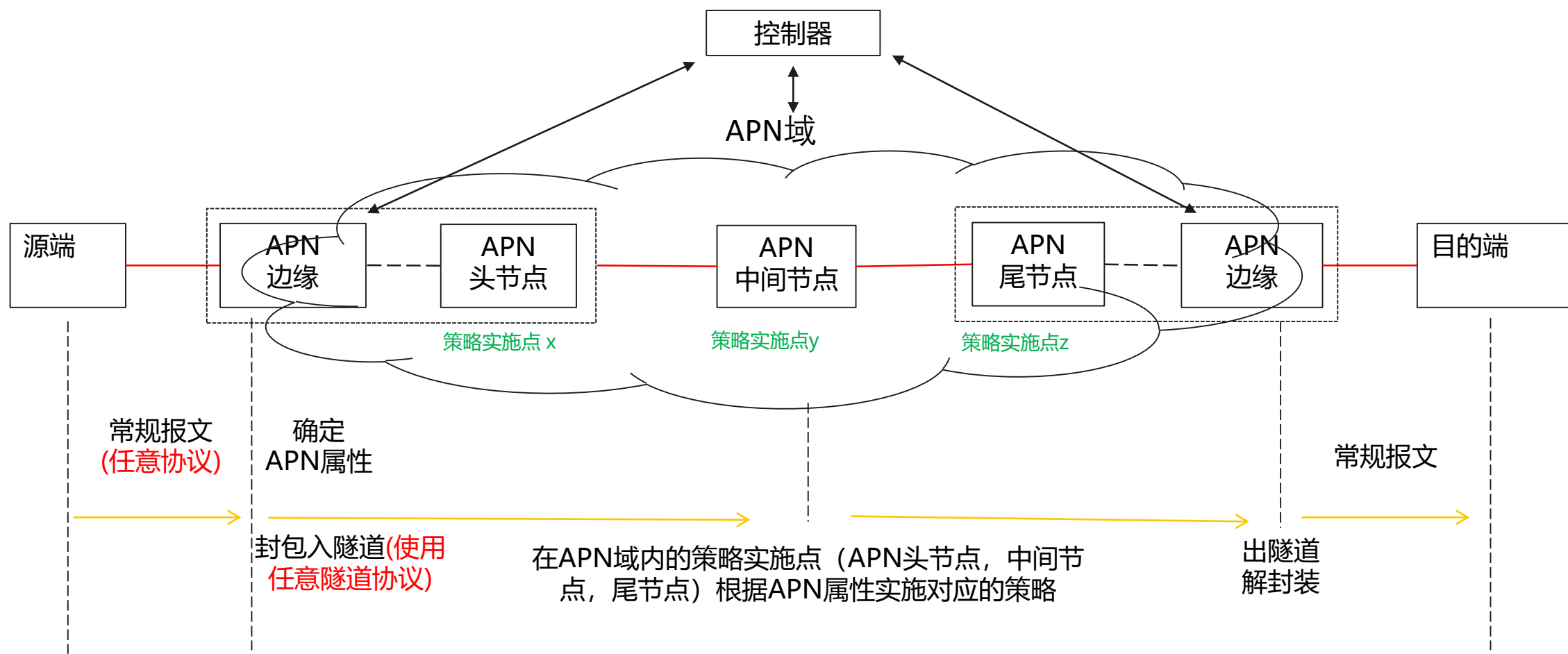
感知应用的 (Application-aware) IPv6网络

- 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



<https://tools.ietf.org/html/draft-li-6man-service-aware-ipv6-network-00> IETF104@Prague

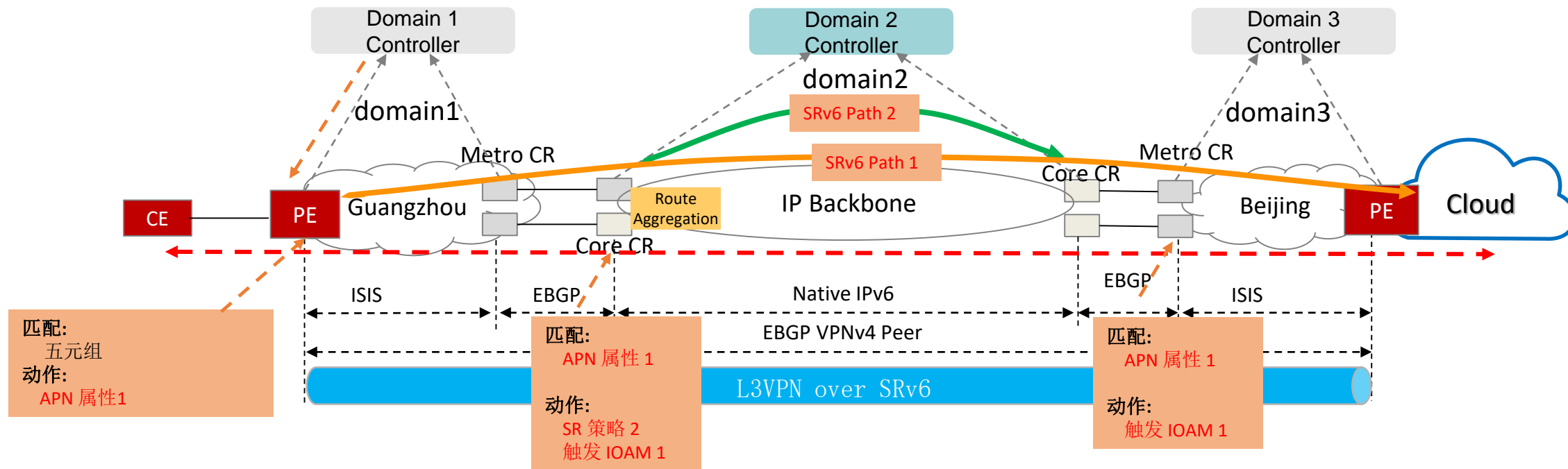
APN网络侧方案网络参考架构图



APN域可以横跨同一个运营者控制的多个网络域

基于APN的IP骨干网的流量引导

- 入节点将APN属性封入报文头
- 使用APN属性可以方便地在IP骨干网上做精细化的流量引导
 - 比如：为了满足特定的APN属性引导数据包进入时延低的路径
- 可以根据APN属性采取实施其他策略（如IOAM）

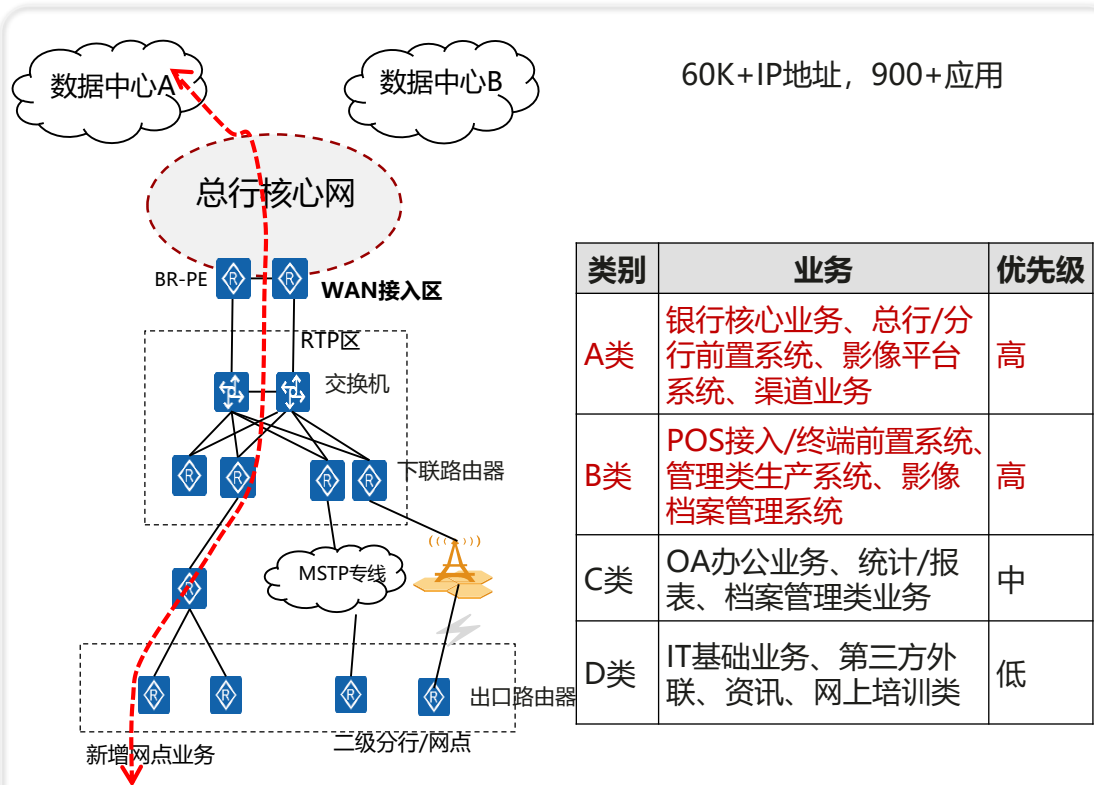


金融：应用级质量可视和保障，通过APN6+iFIT构筑差异化服务能力

行业诉求：在金融，政府（智慧城市）等场景下，应用级体验质量保障，是关键诉求

方案思路：在接入设备上**识别应用打APN6标识**，关键应用/重要视频会议等引流到SRv6隧道；**结合iFIT+APN6实现应用质量可视、质差定界和智能自愈**，提升业务体验

AS IS：缺乏面向应用的差异化服务能力

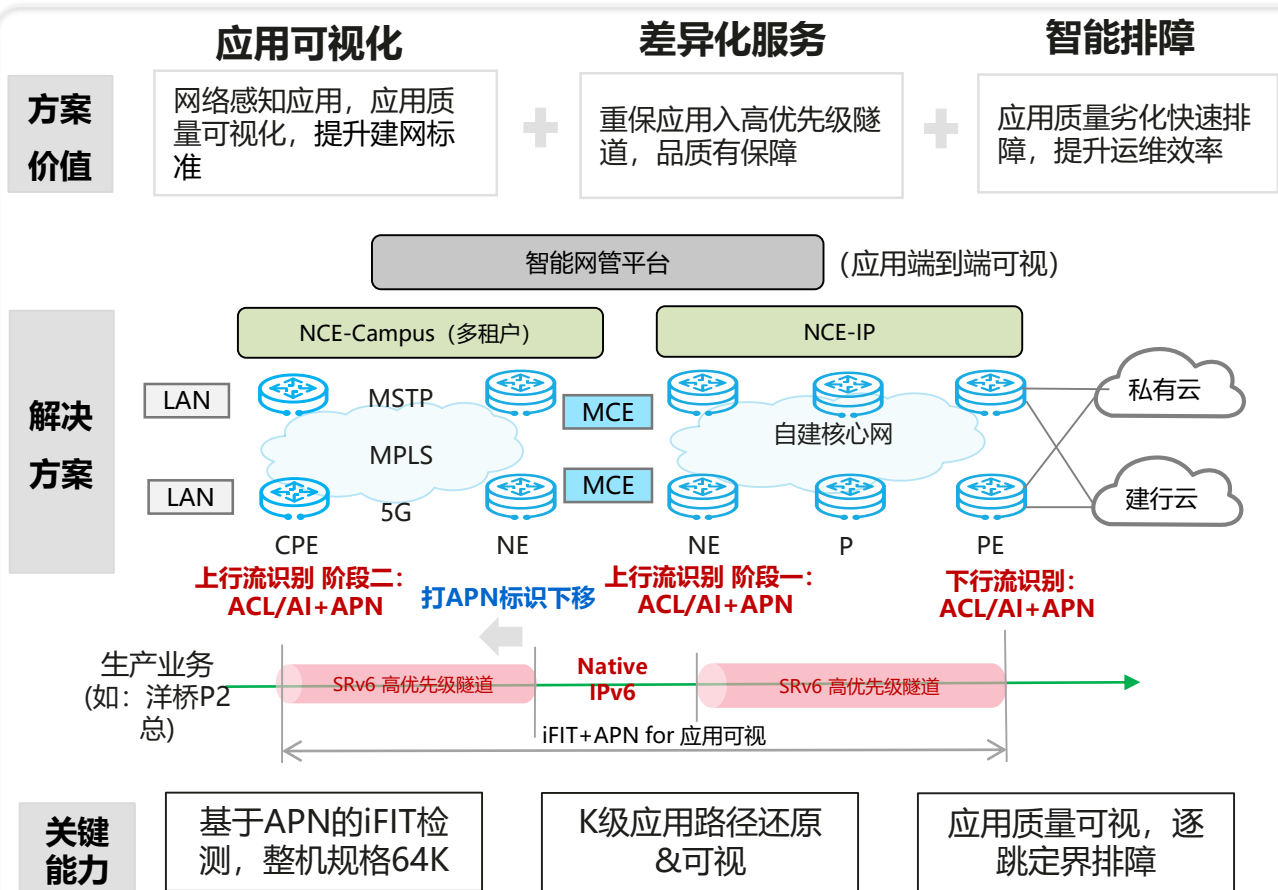


应用统一承载，无法提供差异化服务

应用体验劣化无法快速排障

ACL手工配置导致网络运维复杂

TO BE：网络差异化承载业务，应用质量可视，用户体验有保障

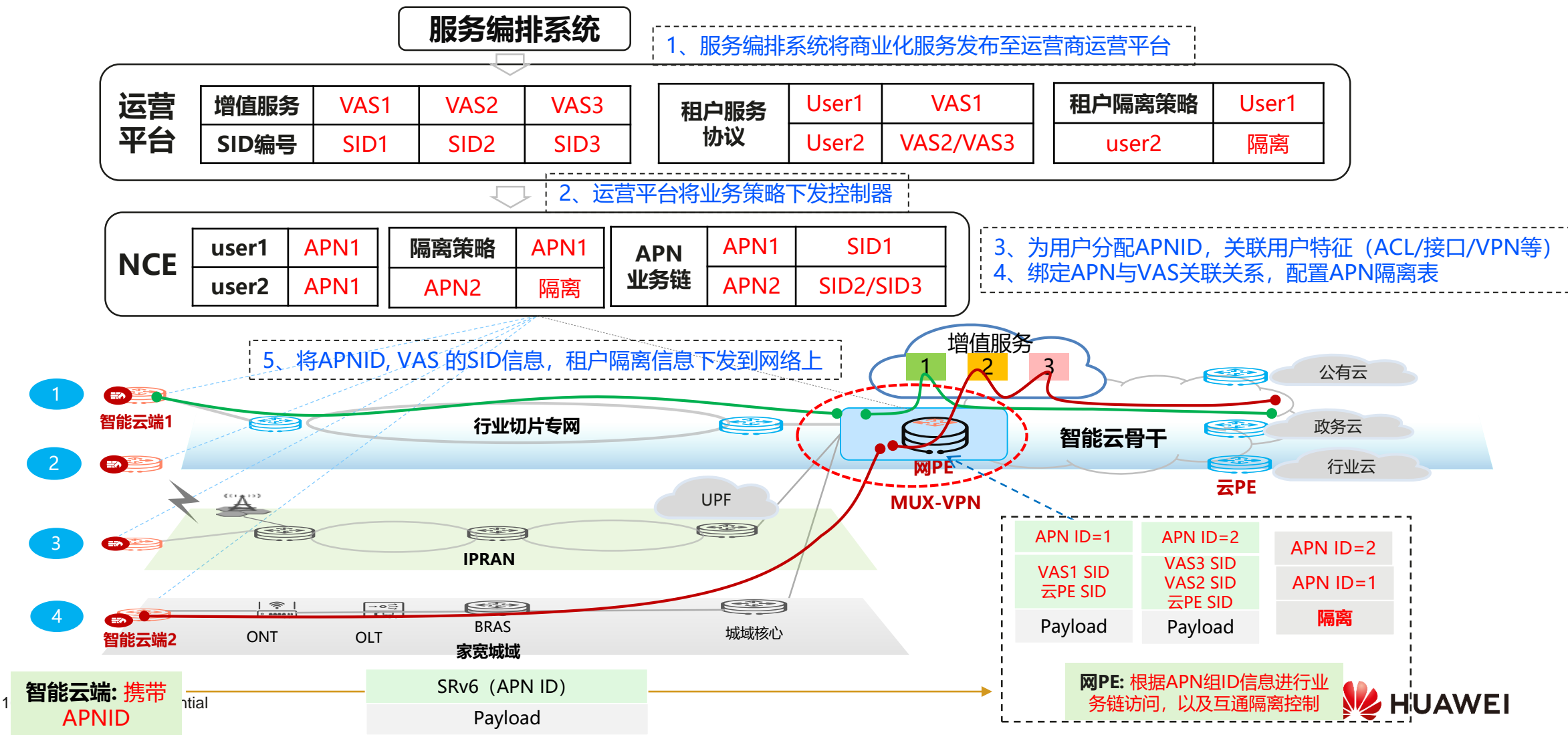


运营商：基于APN6的Mux-VPN方案实现云网安一体

业务变化：随着业务上云，越来越多的增值服务将集中化部署，被用户所灵活定制；安全业务是企业重点的诉求，租户间的隔离诉求非常普遍

关键挑战：当前采用ACL做业务访问控制，及通过ACL做租户隔离控制，消耗大量ACL，硬件成本高，业务扩展性很差，后期维护代价巨大

方案思路：通过APN6 实现业务链的处理，用APNID做租户的标识；以及基于APNID做用户间的隔离控制，可以极大简化配置，降低ACL资源诉求。



APN赢得产业共识， APN BOF成功举行

- Side Meetings @IETF105 & IETF108
- Hackathons @IETF108 & IETF109 & IETF110
- Demos @INFOCOM2020 & 2021
- APN Mailing List Discussions - apn@ietf.org
- APN Interim Meeting @IETF 110-111
- APN BoF @IETF111, Approved! 30 July 2021, 1200-1400 PDT

IETF111 APN BoF

Friday, July 30, 2021			
11:00-18:00	Gather	Secretariat "Registration" Desk	🔗 📍 📅
12:00-18:00	Gather	IANA Office Hours	🔗 📍 📅
12:00-18:00	Gather	RFC Editor Office Hours	🔗 📍 📅
12:00-14:00 Friday Session I			
Room 1	art	webtrass WebTransport	🔗 📍 📅
Room 2	int	add Adaptive DNS Discovery	🔗 📍 📅
Room 3	inf	gaia Global Access to the Internet for All	🔗 📍 📅
Room 4	ops	mboned MBONE Deployment	🔗 📍 📅
Room 5	rtg	apn Application-aware Networking	🔗 📍 📅
Room 6	sec	suit Software Updates for Internet of Things	🔗 📍 📅



IETF108

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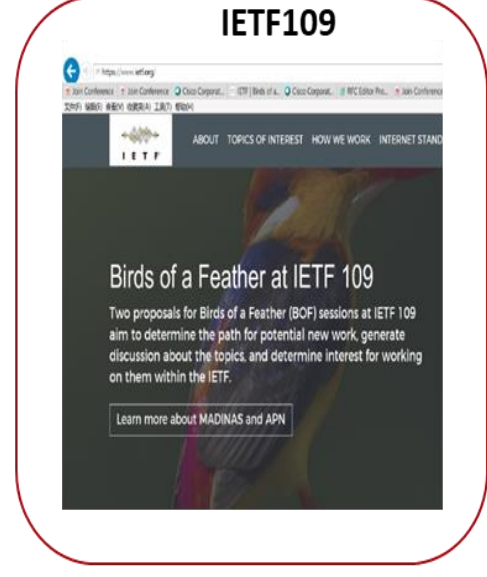
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Georgios Karagiannis, (Huawei)



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

<https://www.ietf.org/blog/ietf109-bofs/>
<https://www.ietf.org/blog/ietf110-bofs/>
[https://trac.tools.ietf.org/bof/trac/wiki/WikiStart \(IETF111 BoF\)](https://trac.tools.ietf.org/bof/trac/wiki/WikiStart(IETF111%20BoF))



APN相关论文积极影响学术圈

APN6: Application-aware IPv6 Networking

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Abstract—This Demo showcased the Application-aware IPv6 Networking (APN6) framework, which takes advantage of the programmable space in the IPv6/SRv6 (Segment Routing on the IPv6 data plane) encapsulations to convey application characteristics information into the network and make the network aware of applications in order to guarantee their Service Level Agreement (SLA). APN6 is able to resolve the drawbacks and challenges of the traditional application awareness mechanisms in the network. By utilizing the real-time network performance monitoring and measurement enabled by Intelligent Flow Information Telemetry (IFIT) and further enhancing it to make it application-aware, we showed that the VIP 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 SFC stitching application-aware Value Added Service (VAS) together with the network nodes/routers is also demonstrated.

Keywords—IPv6, IFIT, Segment Routing, SRv6, SFC

I. INTRODUCTION

The network operators have been facing the challenges of providing better services to their customers. Nowadays it becomes even more challenging. As 5G and industry verticals evolve, the ever-emerging new services with diverse but demanding requirements such as low latency & high reliability are accessing to the network. Applications such as on-line gaming, live video streaming, and video conferencing have highly demanding requirements on the network performance. Meanwhile, they are the actual revenue-producing applications. The customers of network operators desire to have differentiated SLA guarantee for their various demanding new services. However, the current network operators are still not aware of which applications the traffic traversing their network actually belong to. Therefore, the network infrastructure of the network operators gradually becomes large but dumb pipes. Accordingly the network operators are losing their opportunities of making revenue increase in the 5G era and beyond.

There are already some traditional ways to make the network aware of the applications it carries. However, they all have some drawbacks: 1) Five Tuples are widely used for the traffic matching with Access Control List (ACL)/Policy Based Routing (PBR), but still not enough information for supporting the fine-grained service process, 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 more CAPEX and OPEX will be introduced as well as security challenges; 3) Orchestration and SDN-based Solution is used in the era of SDN, with the SDN controller being aware of the service requirements of the applications on the network through the interface with the orchestrator and the service requirement used by the controller for traffic

management over the network, but the whole loop is long and time-consuming which is not suitable for fast service provisioning for critical applications.

We proposed Application-aware IPv6 Networking (APN6) framework [1][2][3], which is able to resolve the drawbacks

and challenges of the above-mentioned awareness mechanisms. In this showcase that includes all the key framework and their capabilities. Application characteristics information carries the application flows are steered in tunnels. Utilizing the real-time monitoring and measurement of Information Telemetry (IFIT) [4] make it application-aware in this VIP application's flow can be at from the path with degrading performance to the one that has good quality in order to guarantee Furthermore, we also demonstrated application-aware SFC within the framework

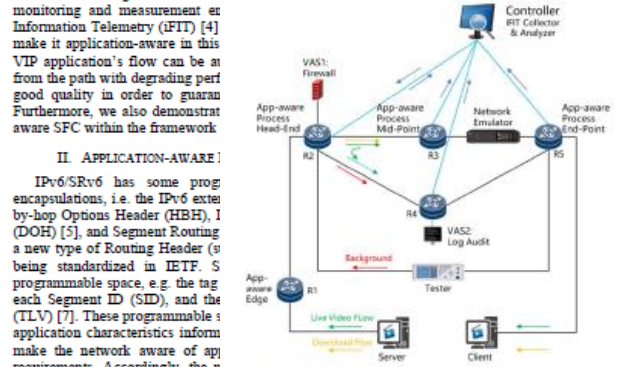


Fig. 2. The APN6 Demo Setup

II. APPLICATION-AWARE

IPv6/SRv6 has some programmable space, i.e. the IPv6 extension by-hop Options Header (HBH), I (DOH) [5], and Segment Routing a new type of Routing Header (S being standardized in IETF. S programmable space, e.g. the tag each Segment ID (SID), and the (TLV) [7]. These programmable space application characteristics inform make the network aware of application requirements. Accordingly, the application flow into corresponding to guarantee its SLA or set up a new one. This is the essential idea of APN6. The application characteristic information includes application-aware 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/User/SLA level. It could also include network performance requirements information, specifying at least one of the following parameters: bandwidth, delay, loss ratio, etc.

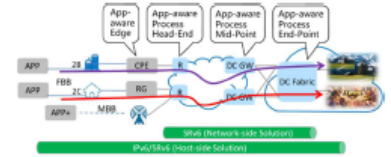


Fig. 1. Application-aware IPv6 Networking Framework and Scenarios

Application-aware G-SRv6 network enabling 5G services

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Abstract—This demo showcased how application-aware G-SRv6 network provides fine-grained traffic steering with more economical IPv6 source routing encapsulation, effectively supporting 5G eMBB, mMTC and uRLLC services. G-SRv6, a new IPv6 source routing paradigm, introduces much less overhead than SRv6 and is fully compatible with SRv6. Up to 75 percent overhead of an SRv6 SID List can be reduced by using 32-bit compressed SID with G-SRv6, allowing most packets to support up to 10 SIDs processing without recirculation, significantly mitigating the hardware processing overhead and facilitating deployments. Furthermore, for the first time, Application-aware IPv6 networking (APN6), the ingress node is able to steer a particular application appropriate G-SRv6 TE policy to guarantee it and save the transmission overhead in the

recirculation. This has become a big obstacle for SRv6 deployment in practice.

We proposed Generalized Segment Routing over IPv6 (G-SRv6) [3][4][5] to address the challenges of SRv6 overhead. While compatible with SRv6, G-SRv6 provides a mechanism to encode Generalized SIDs (G-SID) in the Generalized SRH (G-SRH) where a G-SID can be a 128-bit SRv6 SID or a 32-bit

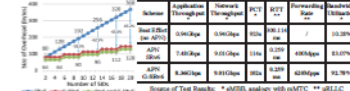


Fig. 2. Comparison between SRv6 and G-SRv6

In order to locate the 32-bit C-SID within the 128-bit space located by Segment Left (SL) in SRH, Segment Index (SI) is defined, and it is the least 2 bits in the argument of the active SID in the IPv6 destination address (DA) field. Furthermore, a Continuation of Compression (COC) flavor is defined [5] to instruct the Segment Endpoint Node to continue to process the 32-bit C-SID in the SRH. When an SRv6 endpoint node receives a SID with COC Flavor, it updates the 32-bit G-SID in the IPv6 DA with the next 32-bit G-SID, and the next G-SID is located at SRH[SI][SI]. Otherwise, the node performs normal SRv6 processing [5]. In application-aware G-SRv6 networks, APN6 ID is added into the IPv6 Hop-by-Hop (HBH) header by application clients and servers to convey the application information to the network layer, so that the network nodes can be aware of the application type of a user group and its requirements. When APN6 packets with APN6 ID are received at the G-SRv6 ingress node, the node steers the packets into corresponding G-SRv6 tunnel based on the APN6 ID and associated policies.

III. DEMONSTRATION

We have implemented APN6 function in Linux kernel to support adding APN6 ID to packets. Next, we enhanced Nginx

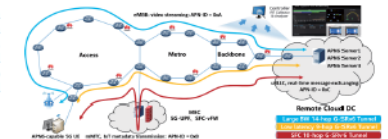


Fig. 3. Application-aware G-SRv6 demo setup

Keywords—SRv6 Compression, G-SRv6, AI

I. INTRODUCTION

As 5G and industry verticals evolve, services with diverse but demanding requirements and high reliability are accessing. Different applications have differentiated network requirements on latency, live video streaming, and video conferencing have highly demanding requirements on both latency and bandwidth. However, in current networks, the unaware of the traffic type traversing their network infrastructure essentially dumb application performance optimization opposite this issue. Application-aware IPv6 networking proposed, which takes advantage of the programmable space in the IPv6/SRv6 packet encapsulations to convey application-aware information into the network layer, and makes network aware of applications and their requirements in order to provide fine-grained application-aware services.

SRv6 [2], as the underlying network protocol supporting APN6, enables the ingress node to explicitly program the forwarding path of packets by encapsulating/inserting ordered Segment ID (SID) list into the Segment Routing Header (SRH) at the ingress node, where each SID is 128-bit long. The SLA can be satisfied by steering the application packets into an explicit SRv6 programmable forwarding path. However, in some scenarios such as strict Traffic Engineering (TE), many SIDs will have to be inserted in the SRH, resulting in a lengthy SRH which imposes big challenges on the hardware processing, and affects the transmission efficiency especially for the small size packets in 5G uRLLC or mMTC scenarios. For instance, the size of an SRv6 encapsulation with 10 SIDs is 208 bytes,

Normally, SRv6 SIDs are allocated from an address block within an SRv6 domain, so the SIDs share the common prefix (CP) of the address block [5]. An SRv6 SID has the format shown in Fig. 1.

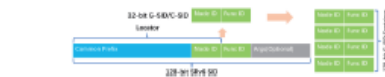


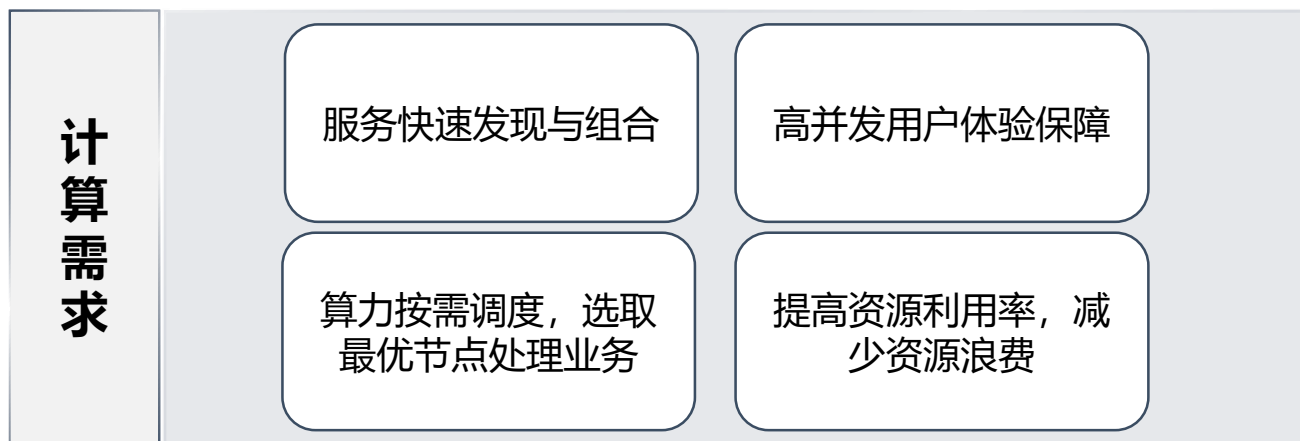
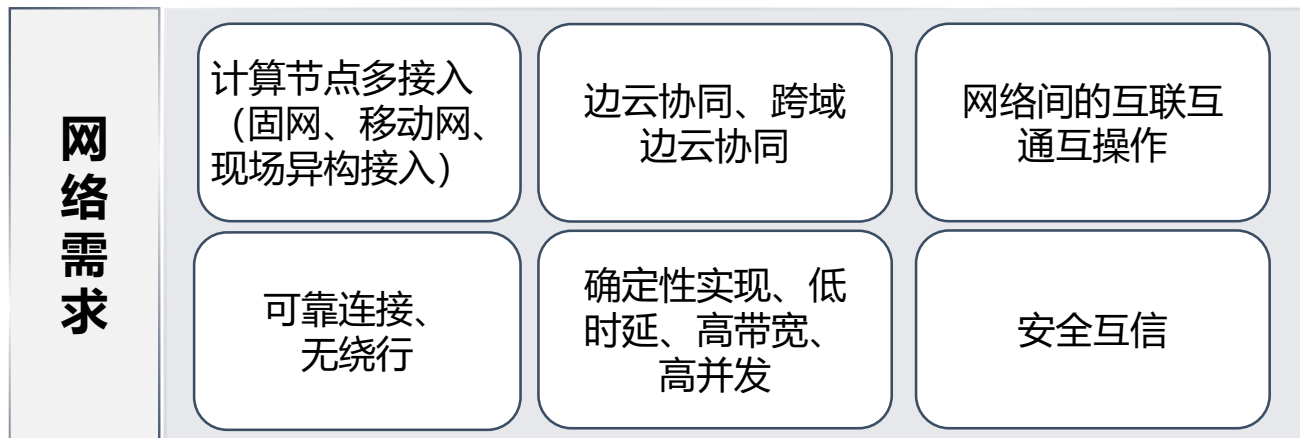
Fig. 1. Format of the 128-bit SRv6 SID and 32-bit G-SID

In most cases, only Node ID and Function ID are different among the SIDs in a SID list, while the common prefix and argument parts are redundant. Removing the redundant parts of the SID list can reduce the overhead. Generalized SRv6 (G-SRv6) realizes this idea. It only carries the compressed SID consisting of node ID and Function ID in the SRH, so that the size of the SRH is compressed. Theoretically, up to 75%

目录

- IPv6+与算力网络
- 感知应用的网络（APN）
- **感知算力的网络（CAN）**
- 总结

算网一体需要网络与算力的联合优化调度



典型应用：MEC中的AR/VR – 根据算力和网络状态综合调度引流

MTP(motion-to-photon)时延上限: 包括帧渲染, 时延需要少于**20 ms**以避免用户眩晕感, 端到端时延组成如下:

1. 传感器采样时延: <1.5ms (客户端)
2. 显示刷新时延: ≈ 7.9 ms(客户端)
3. 使用GPU进行帧渲染计算时延 ≈ 5.5 ms (服务器)
4. 网络时延(预算) = $20 - 1.5 - 7.9 - 5.5 = 5.1$ ms(网络)

计算时延和网络时延同等重要!!

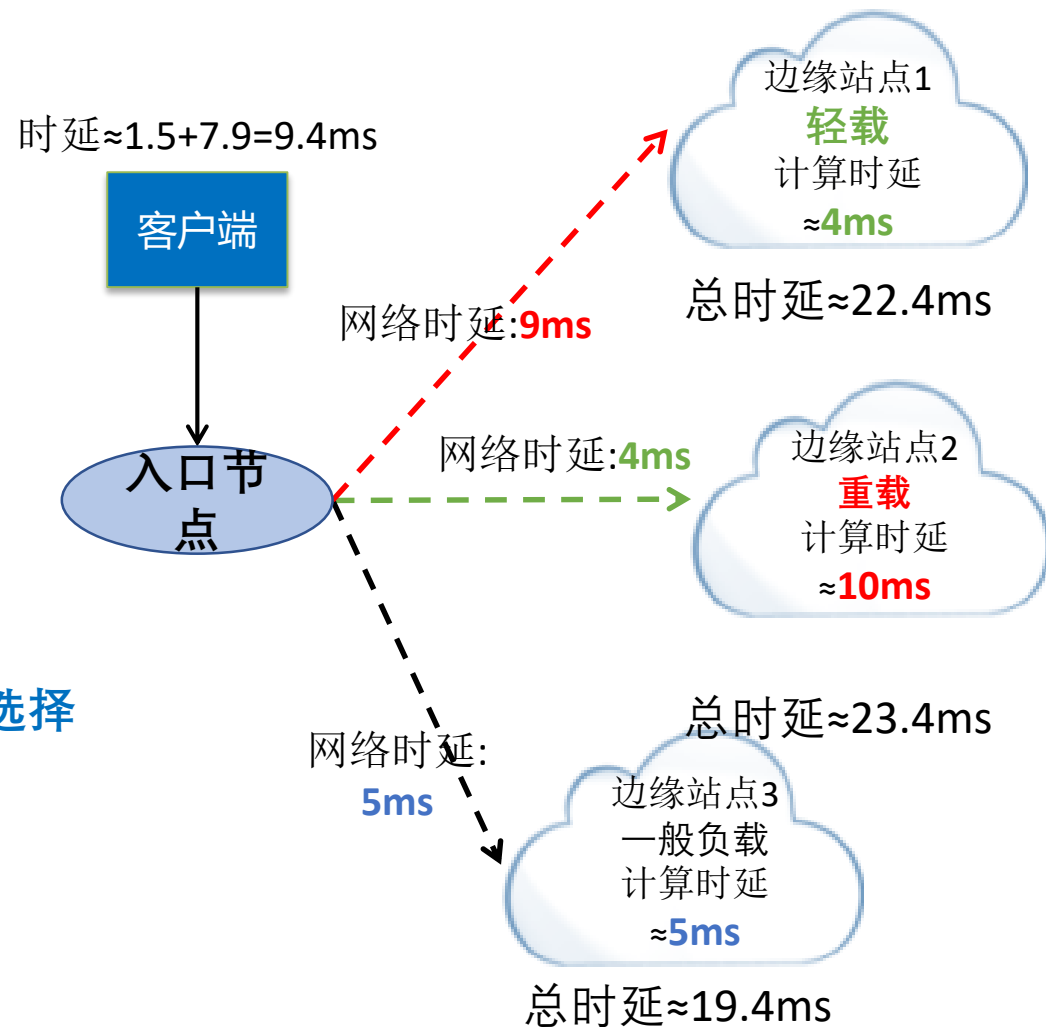


- 只根据计算负载选择边缘站点1, 总时延 ≈ 22.4 ms
- 只根据网络时延选择边缘站点2, 总时延 ≈ 23.4 ms
- 同时根据计算负载和网络时延选择边缘站点, 总时延 ≈ 19.4 ms

仅通过优化网络或计算资源无法满足总时延要求, 无法找到最佳选择



需要将流量动态引导到合适的边缘节点以在同时考虑网络 and 计算延迟的情况下满足端到端时延要求



Dyncast: CAN分布式算网一体统一调度

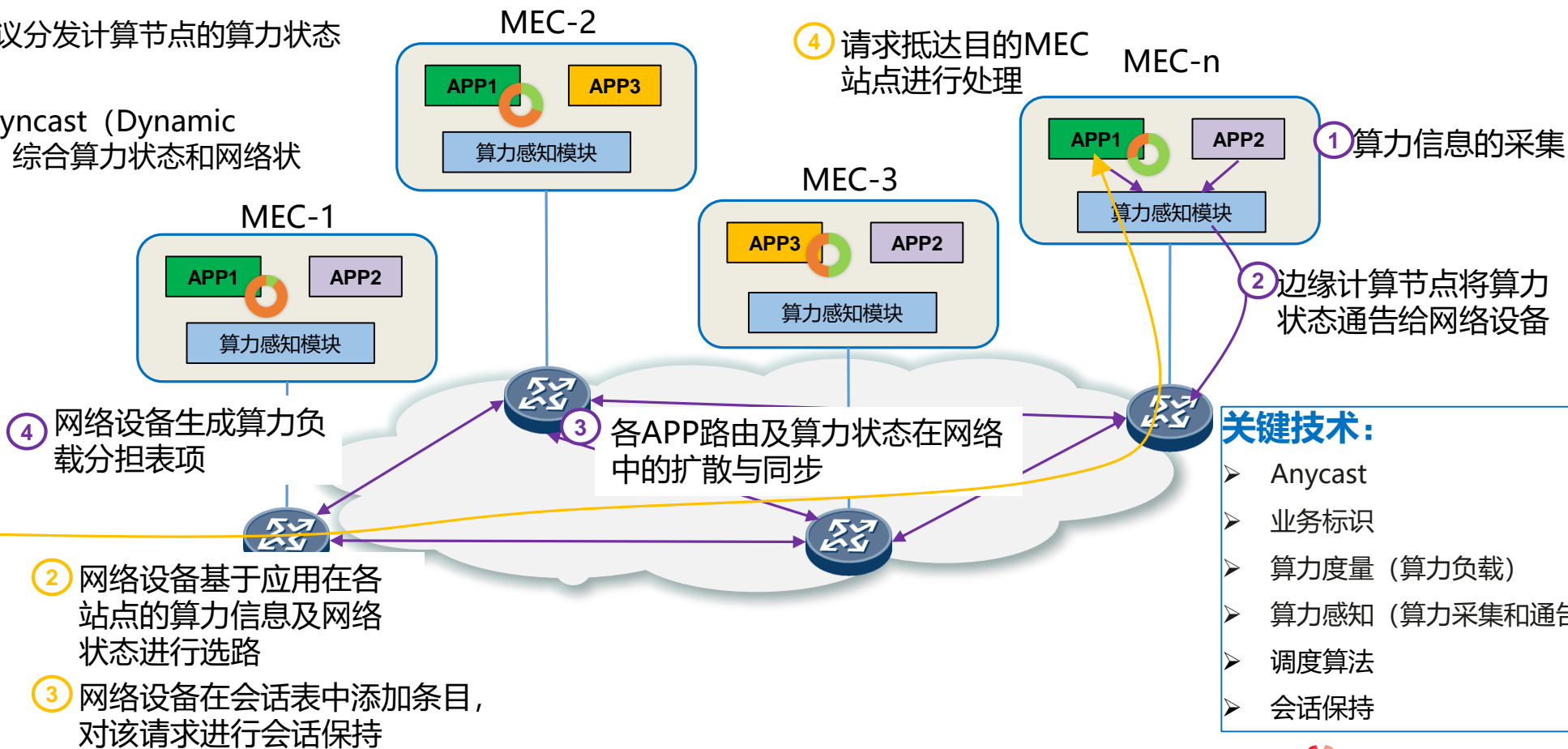
CAN Dyncast (Dynamic Anycast) 是算力路由的一种关键技术, 继承Anycast的快, 可靠, 防DDOS的优点。

- 分布化的算力作为算力网络中的内生资源, 通过动态任播CAN Dyncast拉通联接成网, 为客户提供最佳的算力分配及网络连接实现**边缘计算高可靠性**、**系统整体利用效率最优**

控制面: 通过网络协议分发计算节点的算力状态信息, 如BGP

数据面: 基于CAN Dyncast (Dynamic Anycast) 服务标识、综合算力状态和网络状态引导请求转发

IP 前缀	下一跳	CFN 算力值
APP1 Anycast IP	MEC-1	60
	MEC-2	20
	MEC-n	10



① 用户发起对APP1的请求

② 网络设备基于应用在各站点的算力信息及网络状态进行选路

③ 网络设备在会话表中添加条目, 对该请求进行会话保持

关键技术:

- Anycast
- 业务标识
- 算力度量 (算力负载)
- 算力感知 (算力采集和通告)
- 调度算法
- 会话保持

IETF标准进展: CAN BOF

会议

- **Dyncast Side Meeting @IETF109 & @IETF110**
 - <https://github.com/dyncast/ietf109>
 - <https://github.com/dyncast/ietf110>
- **CAN BOF @IETF113**
 - <https://datatracker.ietf.org/group/can/about/>



The screenshot shows the IETF website navigation bar with 'Groups', 'Documents', 'Meetings', and 'Other' tabs. The 'Groups' tab is active, displaying the 'Computing-Aware Networking (can)' group page. The page includes a navigation menu with 'About', 'Documents', 'Meetings', 'History', 'Photos', 'Email expansions', and 'List archive >'. The main content area lists group details: Name (Computing-Aware Networking), Acronym (can), Area (Routing Area (rtg)), State (BOF), Charter (None), and Dependencies (Document dependency graph (SVG)). Personnel listed include Chairs (Linda Dunbar and Zhaohui Zhang) and Area Director (John Scudder). Mailing list information includes Address (dyncast@ietf.org), To subscribe (https://www.ietf.org/mailman/listinfo/dyncast), and Archive (https://mailarchive.ietf.org/arch/browse/dyncast/). Jabber chat details include Room address (xmpp:can@jabber.ietf.org?join) and Logs (https://jabber.ietf.org/logs/can/).

草案

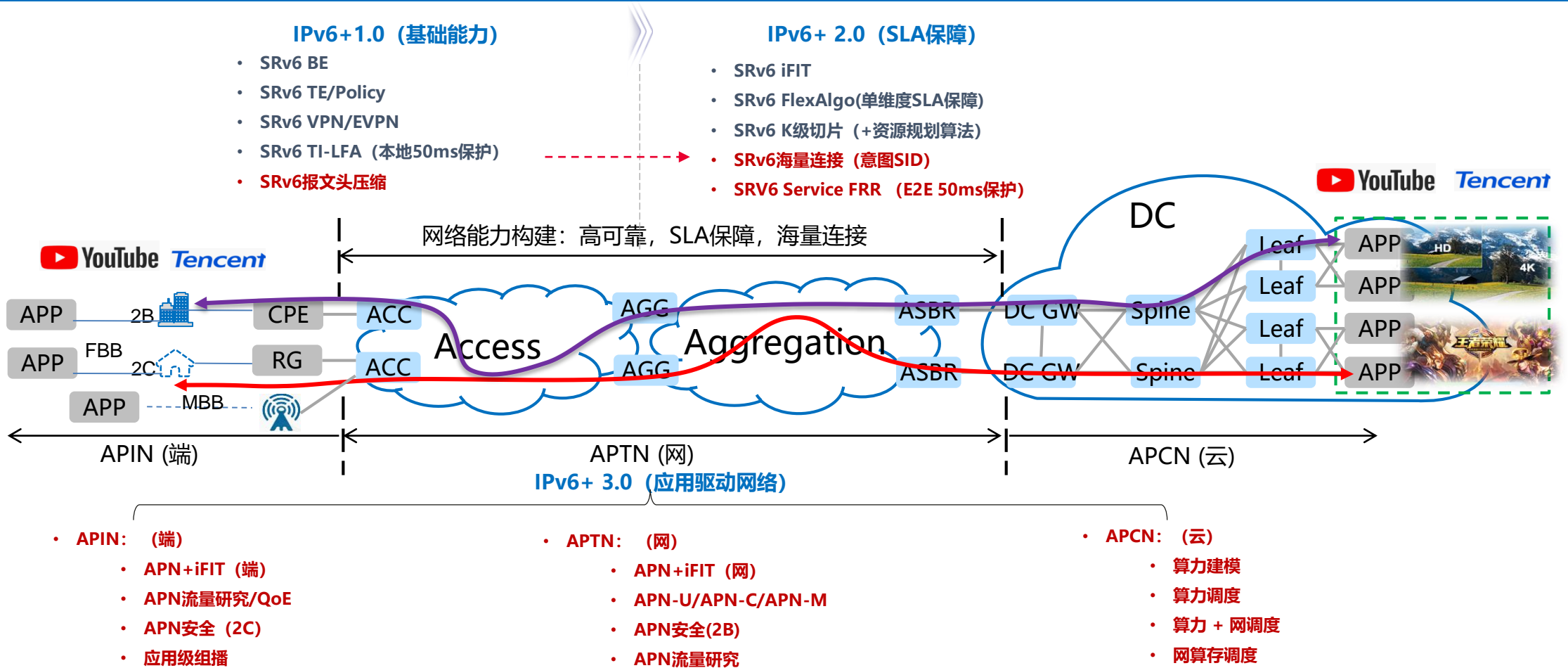
Draft topic	Draft name
Dynamic-Anycast (Dyncast) Use Cases & Problem Statement	draft-liu-dyncast-ps-usecases
Dynamic-Anycast (Dyncast) Requirements	draft-liu-dyncast-reqs
Dynamic-Anycast Architecture	draft-li-dyncast-architecture
Providing Instance Affinity in Dyncast	draft-bormann-dyncast-affinity
LISP Support for Dynamic Anycast Routing	draft-kjsun-lisp-dyncast
BGP NLRI App Meta Data for 5G Edge Computing Service	draft-dunbar-idr-5g-edge-compute-app-meta-data
Computing-aware Networking Use case of ALTO	draft-liu-alto-can-usecase
Use Cases for Computing-aware Software-Defined Wide Area Network(SD-WAN)	draft-zhang-dyncast-computing-aware-sdwan-usecase

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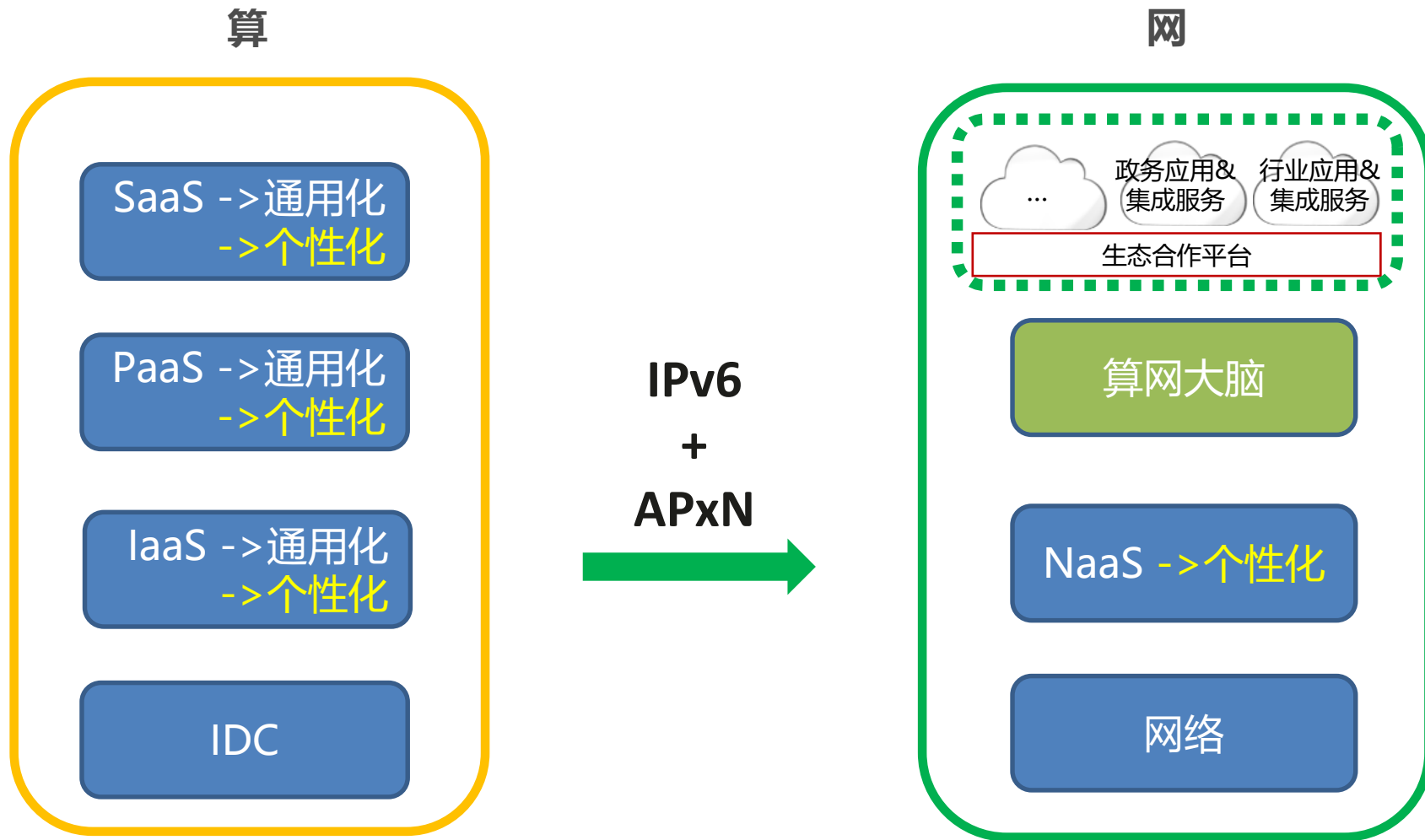
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- **总结**

IPv6+和APxN (APTN/APIN/APCN) 技术体系

IPv6+基本完成网侧能力构建，面对行业网络诉求，向端侧延伸，打造应用感知网络



IPv6 + APxN助力个性化网络满足多样算力的需求



Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home and
organization for a fully connected,
intelligent world.

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