算网一体关键技术研究探索

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- 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，著有《SRv6网络编程：开启IP网络新时代》。
- 2019年3月当选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。2021年3月获得连任，继续承担2021 - 2023年的互联网架构管理工作。

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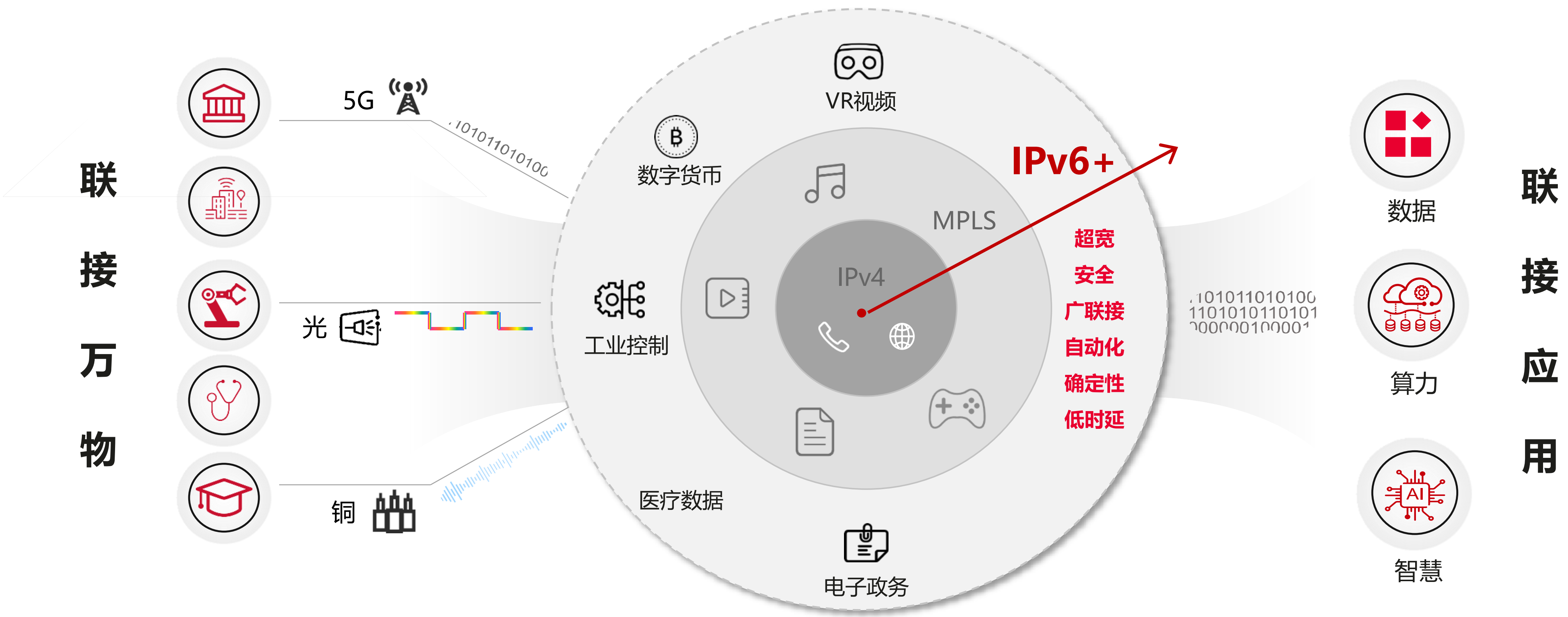
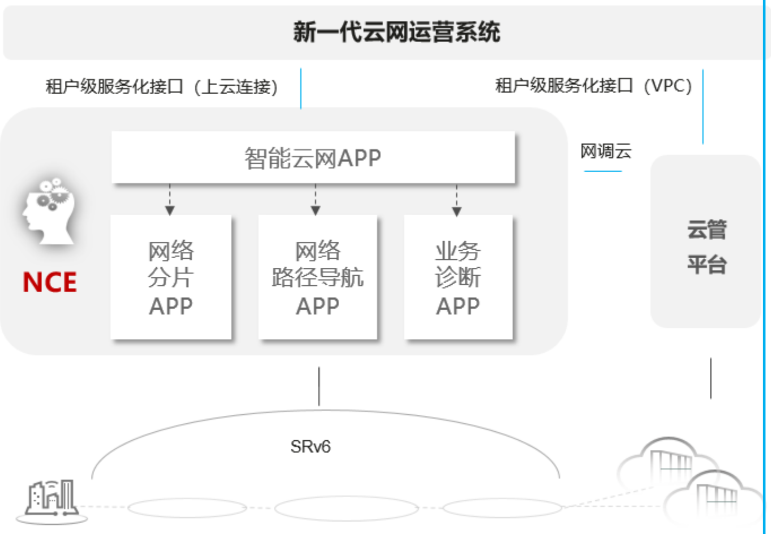
数据通信产业迈向IPv6+智能联接时代



云网协同向算网一体演进

阶段一：泛在协同

云网管控拉通，聚焦网络编程

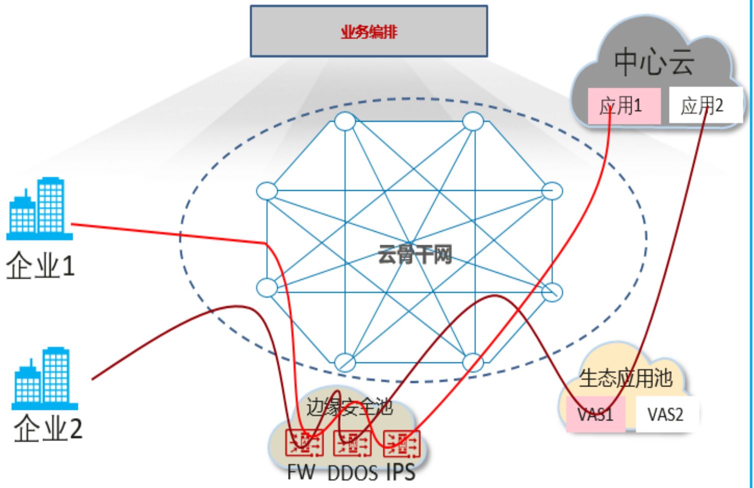


网络分片	网络路径导航	业务诊断
一纤多用	**一跳入云** **一键调优**	**一网可视**

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

阶段二：融合统一

云网业务统一编排



云网业务统一编排：资源池与承载网联动

场景应用：安全应用(FW/IPS/DDOS/WAF等)；广域加速应用(WOC)；视频应用(视频云转码/云加速)；游戏加速，上网监控，时延选路应用

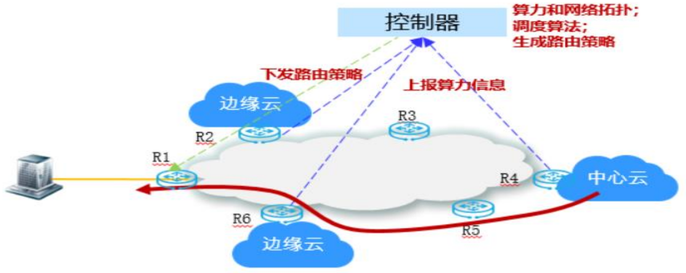
➢ **关键技术：确定性网络、应用感知、业务链**

阶段三：一体内生

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**

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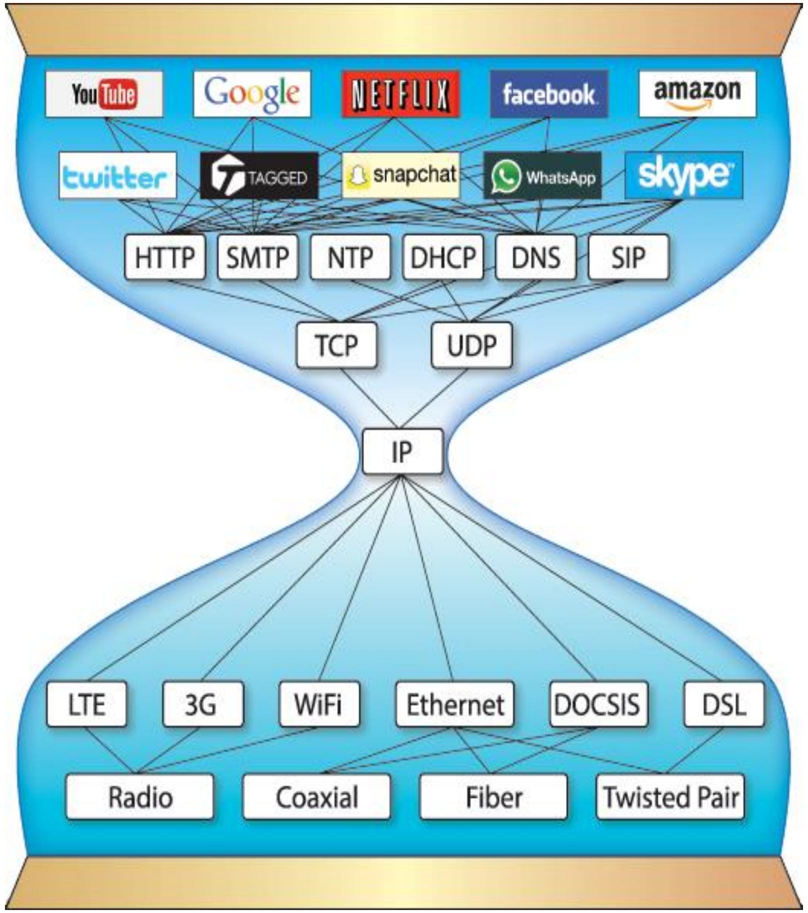
目录

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3：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）	• **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	• **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	• **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

APN6

丰富的网络服务

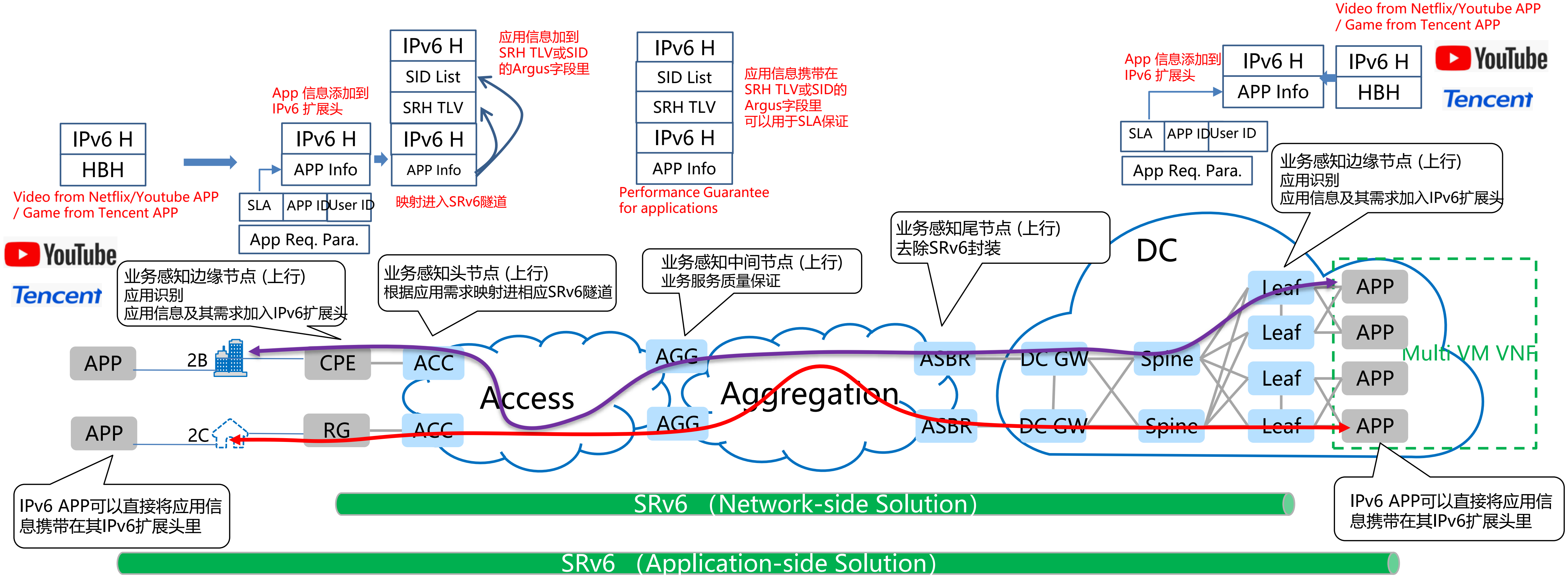
- DiffServ
- H-QoS
- SR Policy
- 网络切片
- DetNet
- SFC
- BIER6

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.)

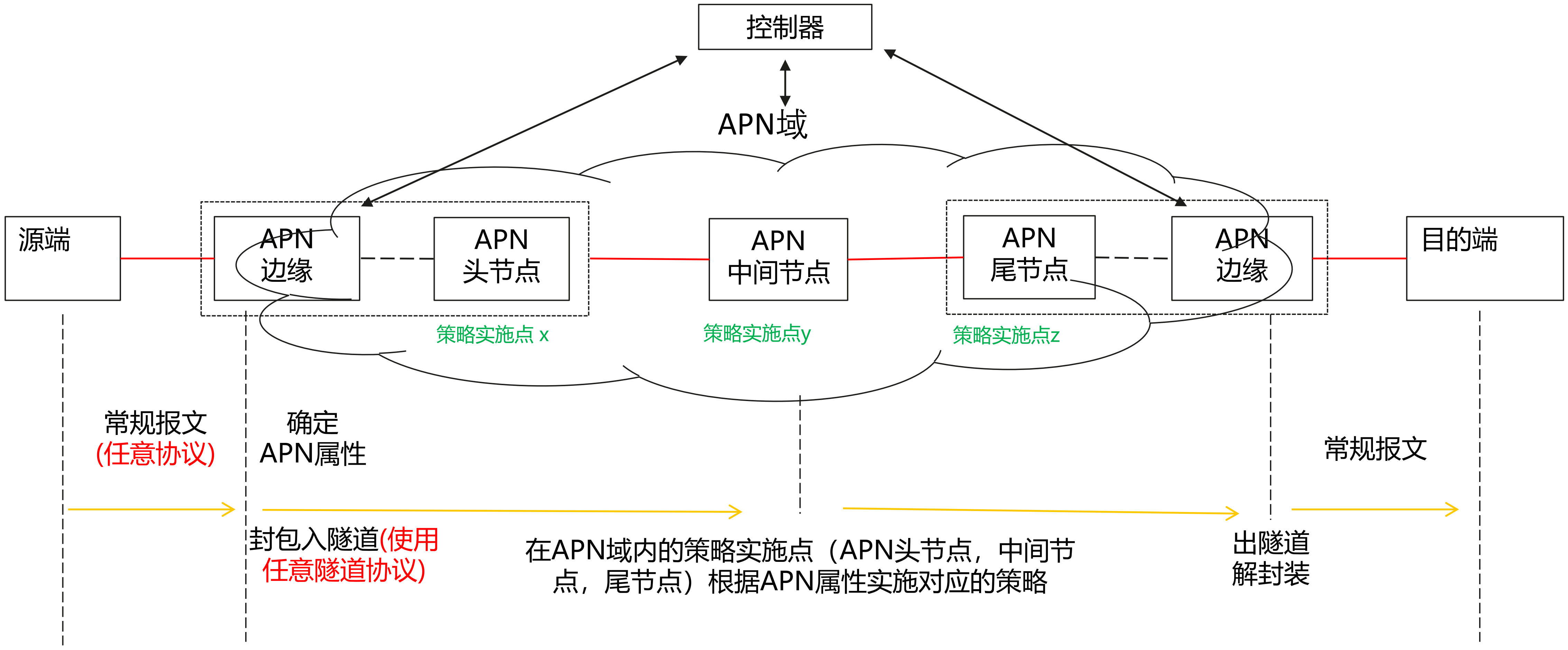
应用感知的（Application-aware）IPv6网络

- 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



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

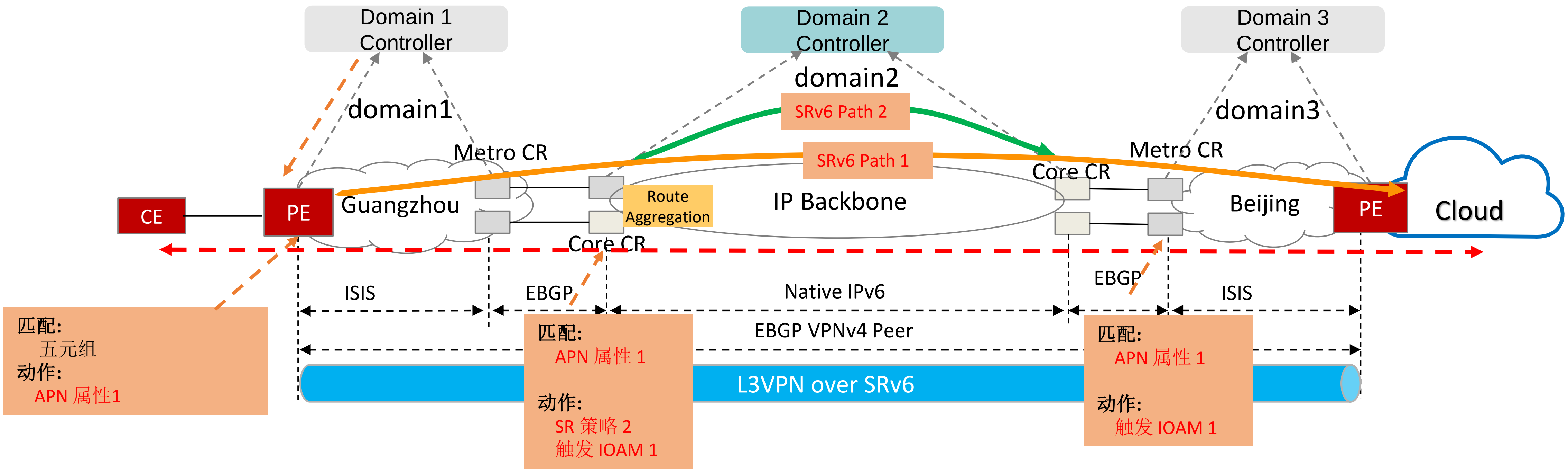
APN网络侧方案网络参考架构图



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）



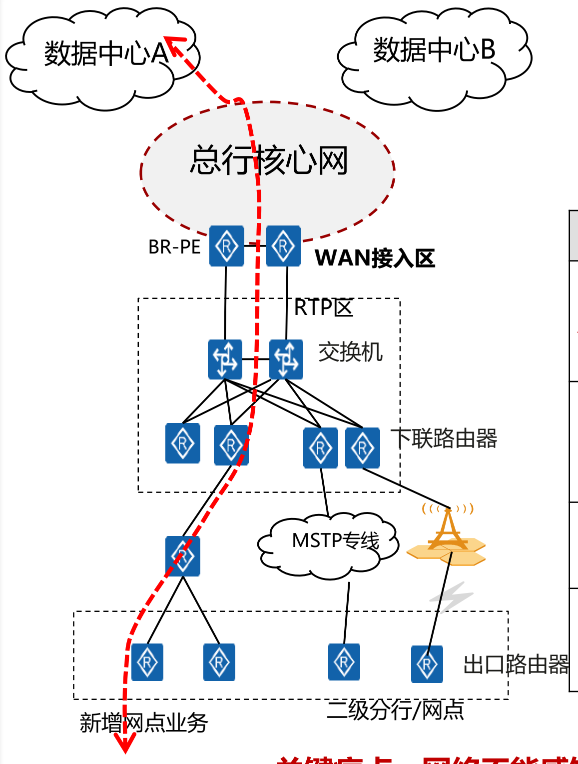
金融：应用级质量可视和保障，通过APN6+iFIT构筑差异化服务能力

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

60K+IP地址，900+应用



类别	业务	优先级
A类	银行核心业务、总行/分行前置系统、影像平台系统、渠道业务	高
B类	POS接入/终端前置系统、管理类生产系统、影像档案管理系统	高
C类	OA办公业务、统计/报表、档案管理类业务	中
D类	IT基础业务、第三方外联、资讯、网上培训类	低

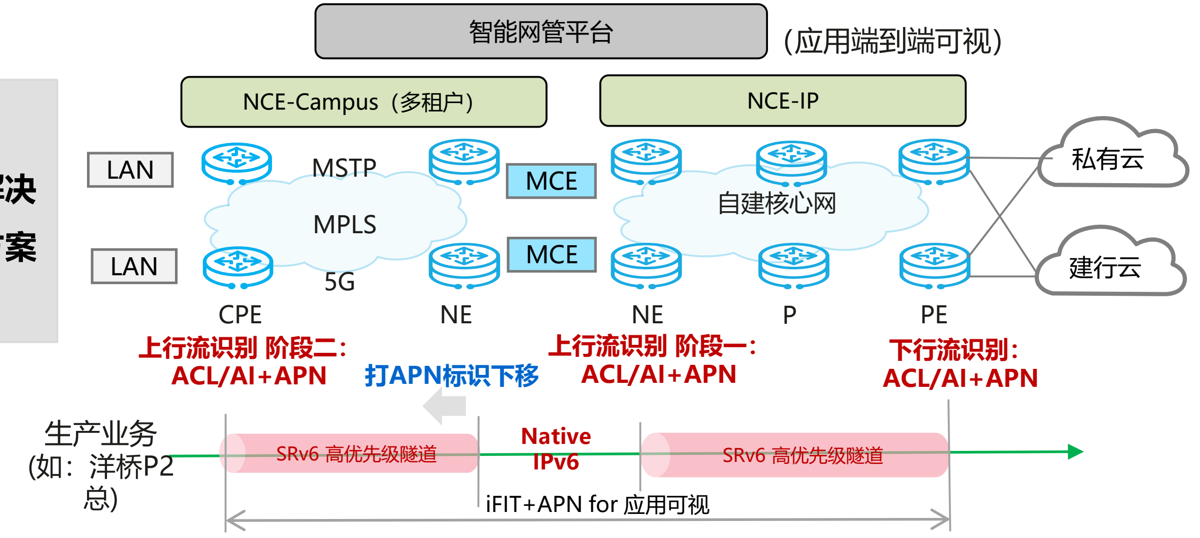
关键痛点：网络不能感知应用，体验无法保障

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

	应用可视化		差异化服务		智能排障
方案价值	网络感知应用，应用质量可视化，提升建网标准	+	重保应用入高优先级隧道，品质有保障	+	应用质量劣化快速排障，提升运维效率

解决方案



关键能力	基于APN的iFIT检测，整机规格64K	K级应用路径还原&可视	应用质量可视，逐跳定界排障

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。

服务编排系统

1、服务编排系统将商业化服务发布至运营商运营平台

运营平台

增值服务	VAS1	VAS2	VAS3
SID编号	SID1	SID2	SID3

租户服务协议	User1	VAS1
	User2	VAS2/VAS3

租户隔离策略	User1
user2	隔离

2、运营平台将业务策略下发控制器

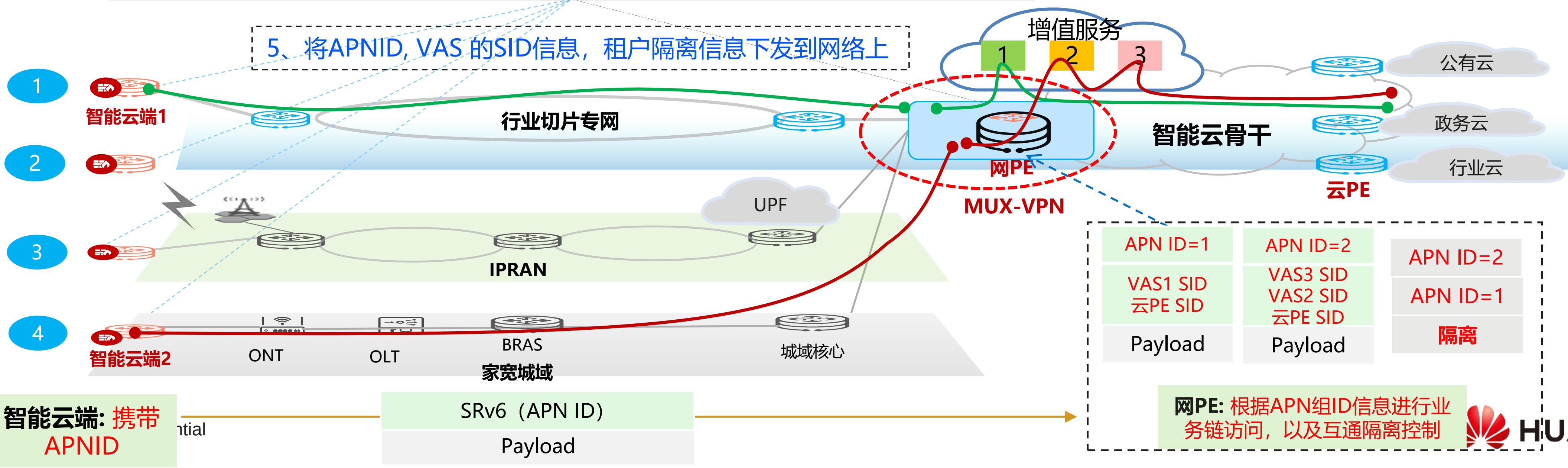
NCE

user1	APN1
user2	APN1

隔离策略	APN1
APN2	隔离

APN业务链	APN1	SID1
	APN2	SID2/SID3

3、为用户分配APNID，关联用户特征（ACL/接口/VPN等）
4、绑定APN与VAS关联关系，配置APN隔离表



APN赢得产业共识，APN BOF成功举行

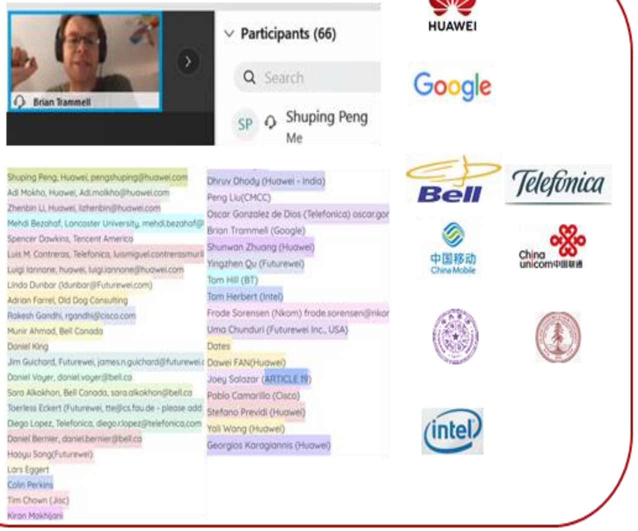
- **Side Meetings** @IETF105 & IETF108
- **Hackathons** @IETF108 & IETF109 & IETF110
- **Demos** @INFOCOM2020 & 2021
- **APN Mailing List** Discussions - apn@ietf.org
- **APN Interim Meeting** @IETF 110-111
- **APN BoF** @IETF111, Approved! 30 July 2021, 1200-1400 PDT

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	webtrans	WebTransport	
Room 2	int	add	Adaptive DNS Discovery	
Room 3	irtf	gaia	Global Access to the Internet for All	
Room 4	ops	mboned	MBONE Deployment	
Room 5	rtg	apn	Application-aware Networking	BOF
Room 6	sec	suit	Software Updates for Internet of Things	

IETF105

IETF108



https://github.com/APN-Community

IETF109

IETF110

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)

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APN相关论文积极影响学术圈

APN6: Application-aware IPv6 Networking

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Huawei Technologies, Beijing, China
pengshuping@huawei.com

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 traditional application awareness mechanisms. In this ... showcase that includes all the ke... framework and their capabilities. ... characteristics information carrie... the application flows are steered i... tunnels. Utilizing the real-tin... monitoring and measurement er... Information Telemetry (iFIT) [4] make it application-aware in this ... VIP application's flow can be a... from the path with degrading perf... good quality in order to guaran... Furthermore, we also demonstrat... aware SFC within the framework

II. APPLICATION-AWARE I...

IPv6/SRv6 has some prog... encapsulations, i.e. the IPv6 exte... 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 s... application characteristics inform... make the network aware of ap... requirements. Accordingly, the n... application flow into correspondin... 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.

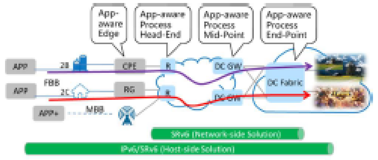

Fig. 1. Application-aware IPv6 Networking Framework and Scenarios

Now the VIP live video streaming is flowing along the path R2-R4-R5, which has deployed a VAS2: Log Audit at R4 against the VIP Application-aware ID 1. The video streaming flow will be audited accordingly. Therefore, we demonstrated the flexible application-aware SFC stitching application-aware VAS together with the network nodes/routers.

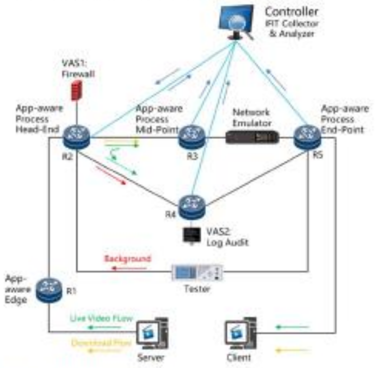

Fig. 2. The APN6 Demo Setup

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 merchant chipsets to support up to 10 SIDs processing without recirculation, significantly mitigating the c... hardware processing overhead and facilitati... deployments. Furthermore, for the first time, Application-aware IPv6 networking (APN6), t... ingress node is able to steer a particular appl... appropriate G-SRv6 TE policy to guarantee it... and save the transmission overhead in the me...**

Keywords—SRv6 Compression, G-SRv6, A...

I. INTRODUCTION

As 5G and industry verticals evolve, ... services with diverse but demanding require... latency and high reliability are accessing ... Different applications have differentiated net... Agreement (SLA). For instance, on-line ... demanding requirements on latency, live v... high requirements on both latency and bandw... traffic mainly requires more bandwidth but ... latency. However, in current networks, th... unaware of the traffic type traversing their n... network infrastructure essentially dumb ... application performance optimization oppo... this issue, Application-aware IPv6 networ... 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, ...

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 ...

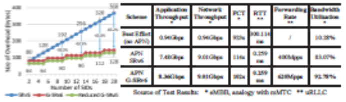


Fig. 2. Comparison between SRv6 and G-SRv6

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[SL][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 ...

102s, 53.33% transmission overhead is reduced, and bandwidth utilization is increased from 83.07% to 92.79%.

2) mMTC, IoT metadata transmission (Payload size: 128 Bytes) over a 10-hop path: Without APN6, the traffic is forwarded following the shortest path. Using APN6 over SRv6/G-SRv6, the traffic is forwarded over the Service Function Chain (SFC) path with a firewall deployed in MEC for security checking. Comparing to SRv6, the SID list (10 SIDs) is compressed from 160 bytes to 64 bytes in G-SRv6. In this situation, the forwarding rate of an SRv6 endpoint node is raised by 55% from 400Mpps to 620Mpps in G-SRv6 due to no packet recirculation.

3) uRLLC, real-time message exchanging traffic (Payload size:128 Bytes) over the 9-hop shortest path: Using APN6, the traffic is forwarded through the lowest latency path, and the latency is shortened from 300.114ms to 0.259ms comparing to another path. Comparing to SRv6, 45.45% transmission overhead is reduced in G-SRv6, and bandwidth utilization is increased from 42.11% to 57.14%.

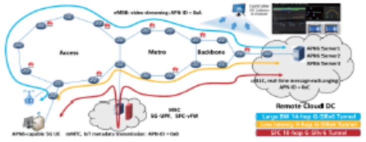


Fig. 3. Application-aware G-SRv6 demo setup

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.

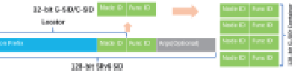


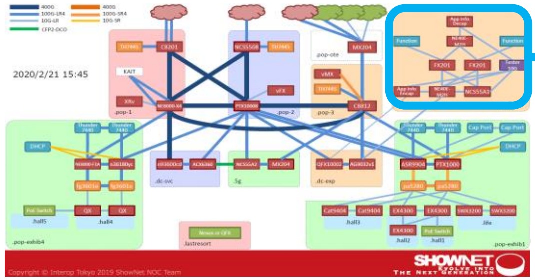
Fig. 1. Format of the 128-bit SRv6 SID and 32-bit G-SID

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% ...

https://ieeexplore.ieee.org/abstract/document/9162934, https://www.youtube.com/watch?v=ONqwxKVmPp0

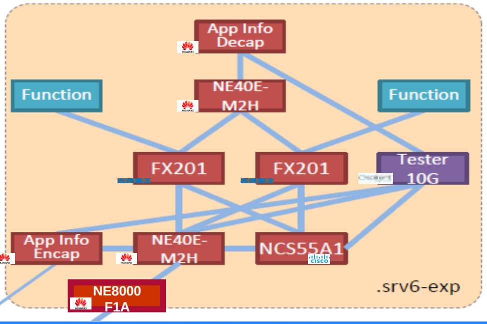
APN6 @Interop Tokyo2020

HUAWEI | cisco | spirent | NTT Communications | 古河電工 | 東京大学 THE UNIVERSITY OF TOKYO



Interop 20 Tokyo

SHOWNET EVOLVE INTO THE NEXT GENERATION



2019.7 — IETF 105 Montreal, 20 Jul 2019 - 26 Jul 2019: APN6 Side Meeting

2019.11 — HUAWEI, cisco, NTT Communications, TOYOTA, 東京大学 THE UNIVERSITY OF TOKYO — IETF 106 Singapore, 16 Nov 2019 - 22 Nov 2019: F2F meeting with Shownet NOC team

2019.12 — HUAWEI, cisco, 古河電工, spirent, NTT Communications, 東京大学 THE UNIVERSITY OF TOKYO — APN POC Collaboration

2020.1 — SHOWNET EVOLVE INTO THE NEXT GENERATION — APN Shownet Setup Plan

2020.2 — SHOWNET EVOLVE INTO THE NEXT GENERATION — APN6 in Shownet Topology

2020.4 — Interop 2020 — Finalist

Interop to Cloud – APN6 Shownet

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目录

算网一体需要网络与算力的联合优化调度

网络需求

- 计算节点多接入（固网、移动网、现场异构接入）
- 边云协同、跨域边云协同
- 网络间的互联互通互操作
- 可靠连接、无绕行
- 确定性实现、低时延、高带宽、高并发
- 安全互信

计算需求

- 服务快速发现与组合
- 高并发用户体验保障
- 算力按需调度，选取最优节点处理业务
- 提高资源利用率，减少资源浪费

算网一体的联合优化调度

- 需求与资源快速建联
- 通信SLA保障
- 资源高效协同
- 云边端算力Fabric

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:

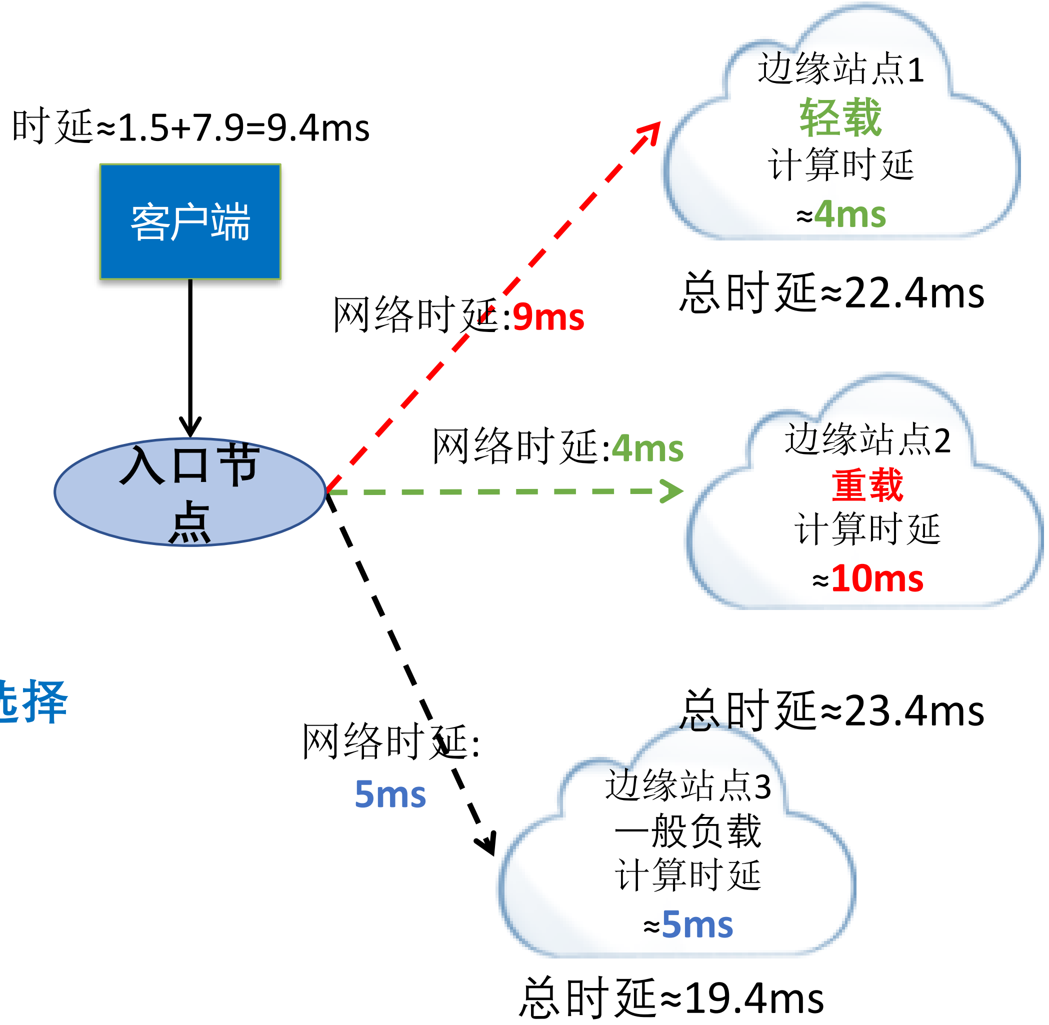
1. 传感器采样时延: <1.5ms (客户端)
2. 显示刷新时延: ≈7.9 ms(客户端)
3. 使用GPU进行帧渲染**计算时延≈ 5.5ms** (服务器)
4. **网络时延**(预算) =20-1.5-7.9-5.5 = **5.1ms**(网络)

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

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**以在同时考虑网络和计算延迟的情况下满足端到端时延要求**



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Dyncast：CAN分布式算网一体统一调度

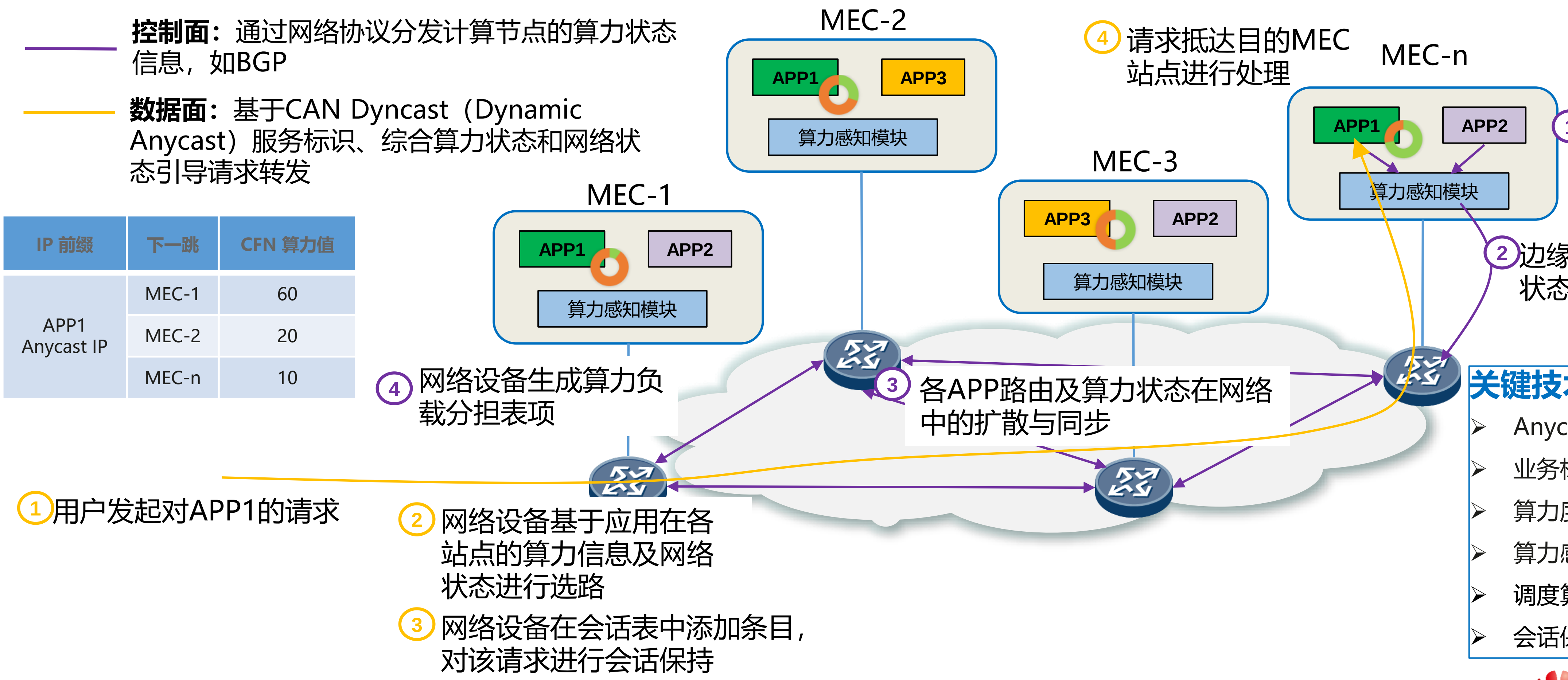
CAN Dyncast（**Dynamic Anycast**）**是算力路由的一种关键技术，继承Anycast的快，可靠，防DDOS的优点。**

- 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



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

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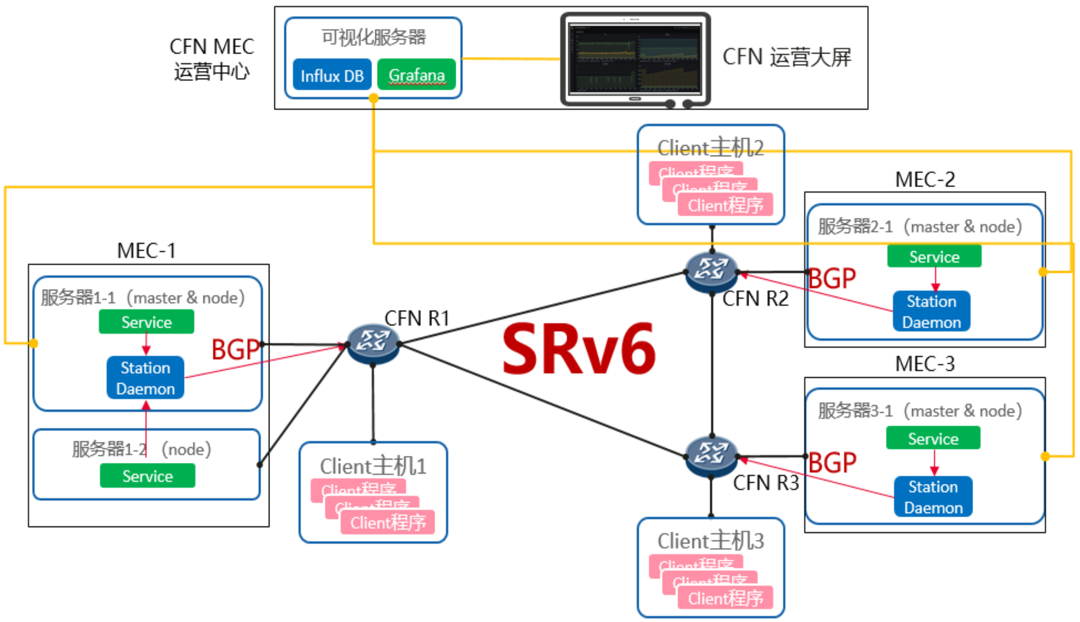
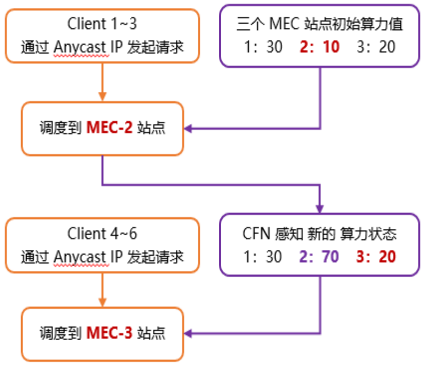
CAN Dyncast原型展示

2020网络5.0峰会、2020边缘计算产业峰会 和中移动联合原型展示基于路由器作为CAN Router的原型进行 CAN Dyncast算力路由方案的展示。





CFN 算力监控大屏

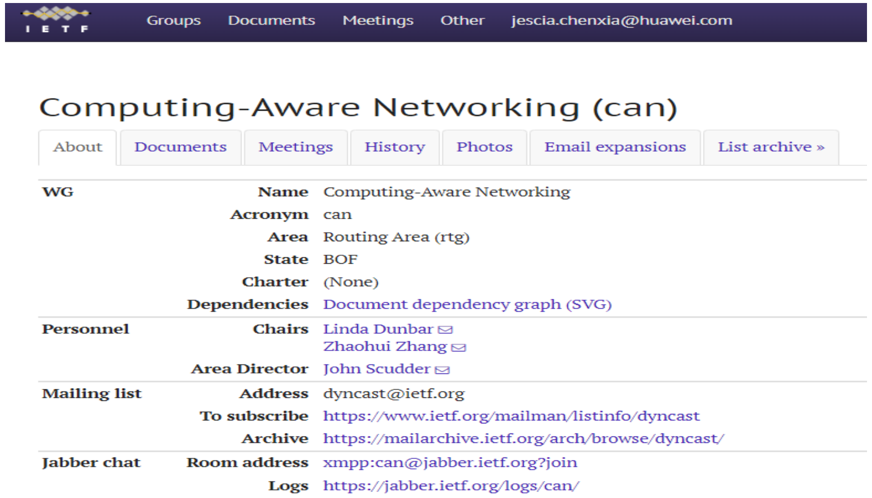
CFN 基础调度功能：向算力状态最佳的站点，调度应用请求

15%⬇	10%⬆	动态负载均衡
任务完成时间	单位时间内，应用完成的任务数	不同容量的 MEC 站点

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/



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

目录

IPv6+和APxN（APTN/APIN/APCN）技术体系

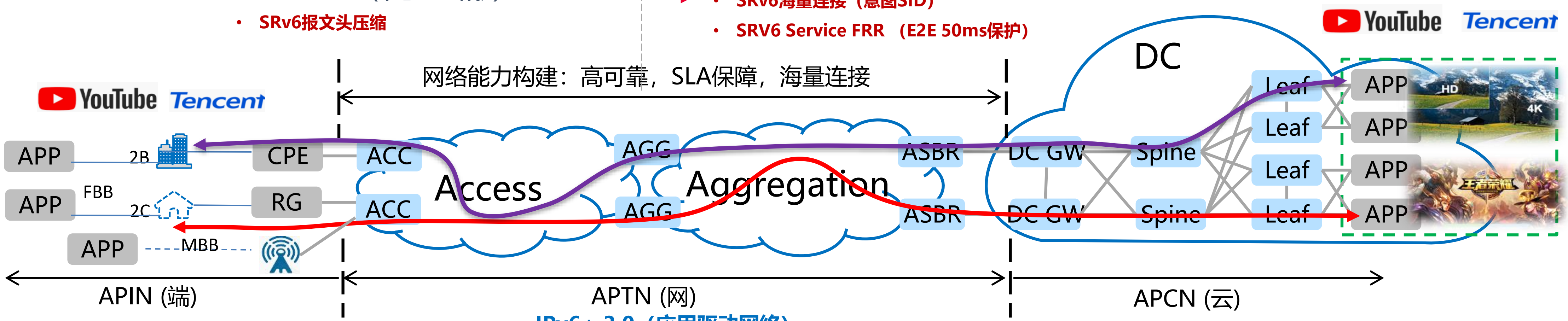
IPv6+基本完成网侧能力构建，面对行业网络诉求，向端侧延伸，打造应用感知网络

IPv6+1.0（基础能力）

- SRv6 BE
- SRv6 TE/Policy
- SRv6 VPN/EVPN
- SRv6 TI-LFA（本地50ms保护）
- SRv6报文头压缩

IPv6+ 2.0（SLA保障）

- SRv6 iFIT
- SRv6 FlexAlgo(单维度SLA保障)
- SRv6 K级切片（+资源规划算法）
- SRv6海量连接（意图SID）
- SRV6 Service FRR （E2E 50ms保护）



IPv6+ 3.0（应用驱动网络）

- APIN： （端）
  - APN+iFIT（端）
  - APN流量研究/QoE
  - APN安全（2C）
  - 应用级组播
- APTN： （网）
  - APN+iFIT（网）
  - APN-U/APN-C/APN-M
  - APN安全(2B)
  - APN流量研究
- APCN： （云）
  - 算力建模
  - 算力调度
  - 算力 + 网调度
  - 网算存调度

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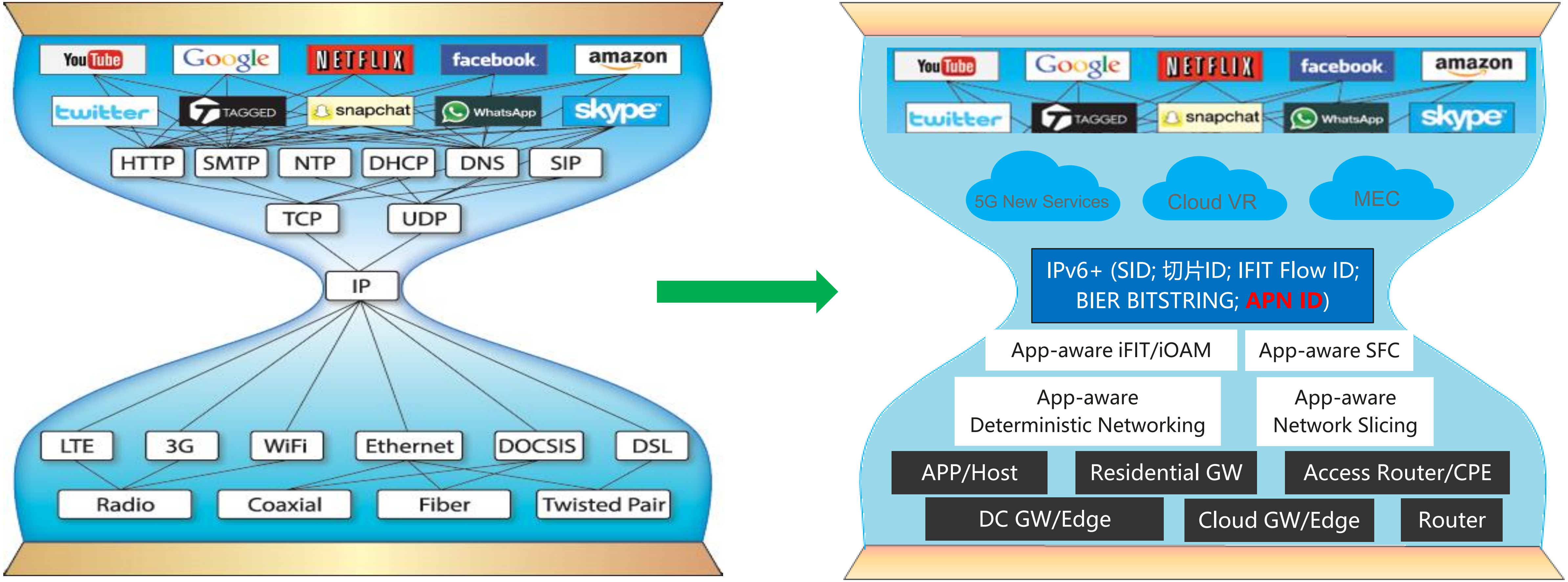
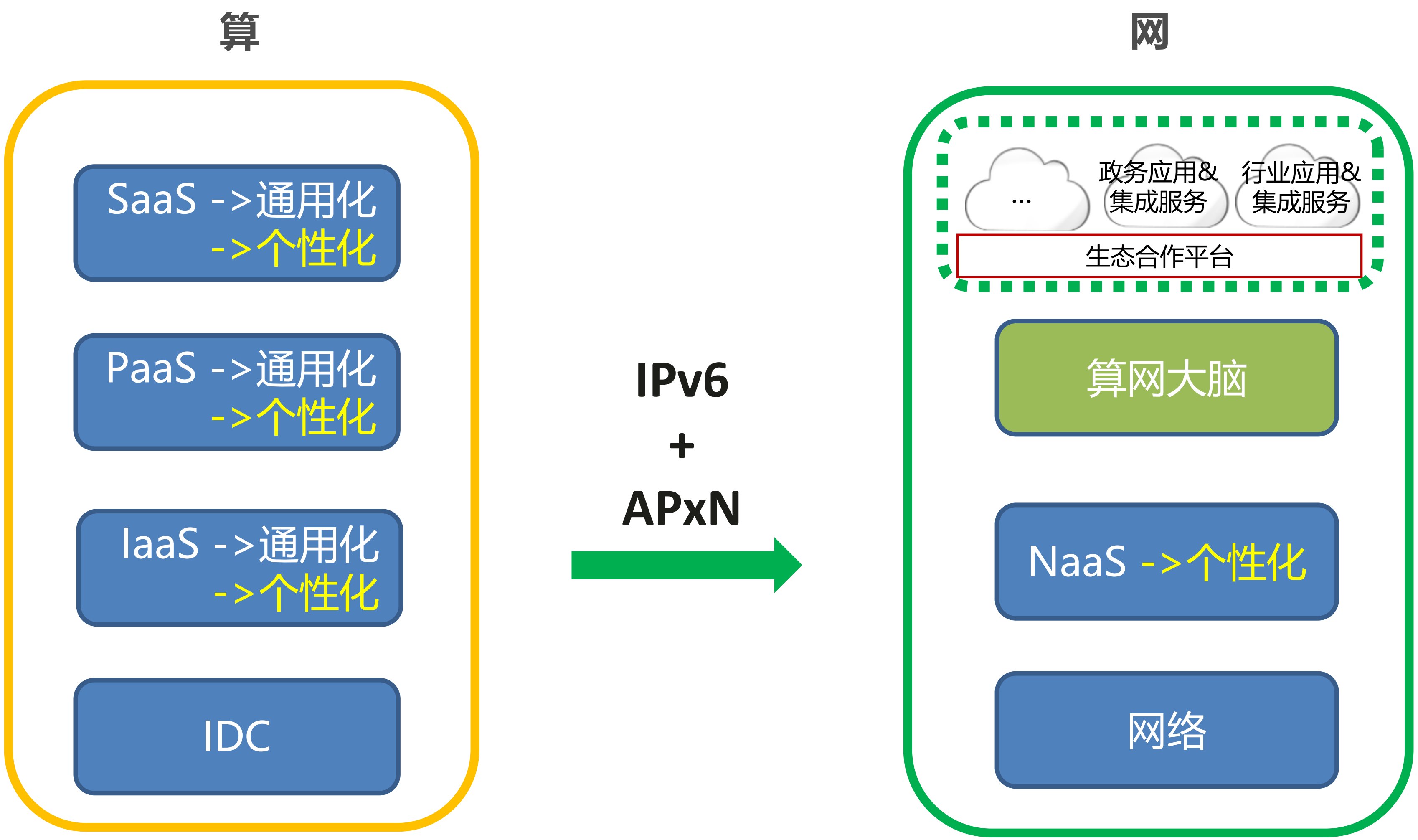
TCP/IP瘦腰模型的改变与基于IPv6的3.5层创新



面向互联网的TCP/IP瘦腰模型 vs. 面向Limited Domain的胖腰模型

IPv6 + APxN助力个性化网络满足多样算力的需求



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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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