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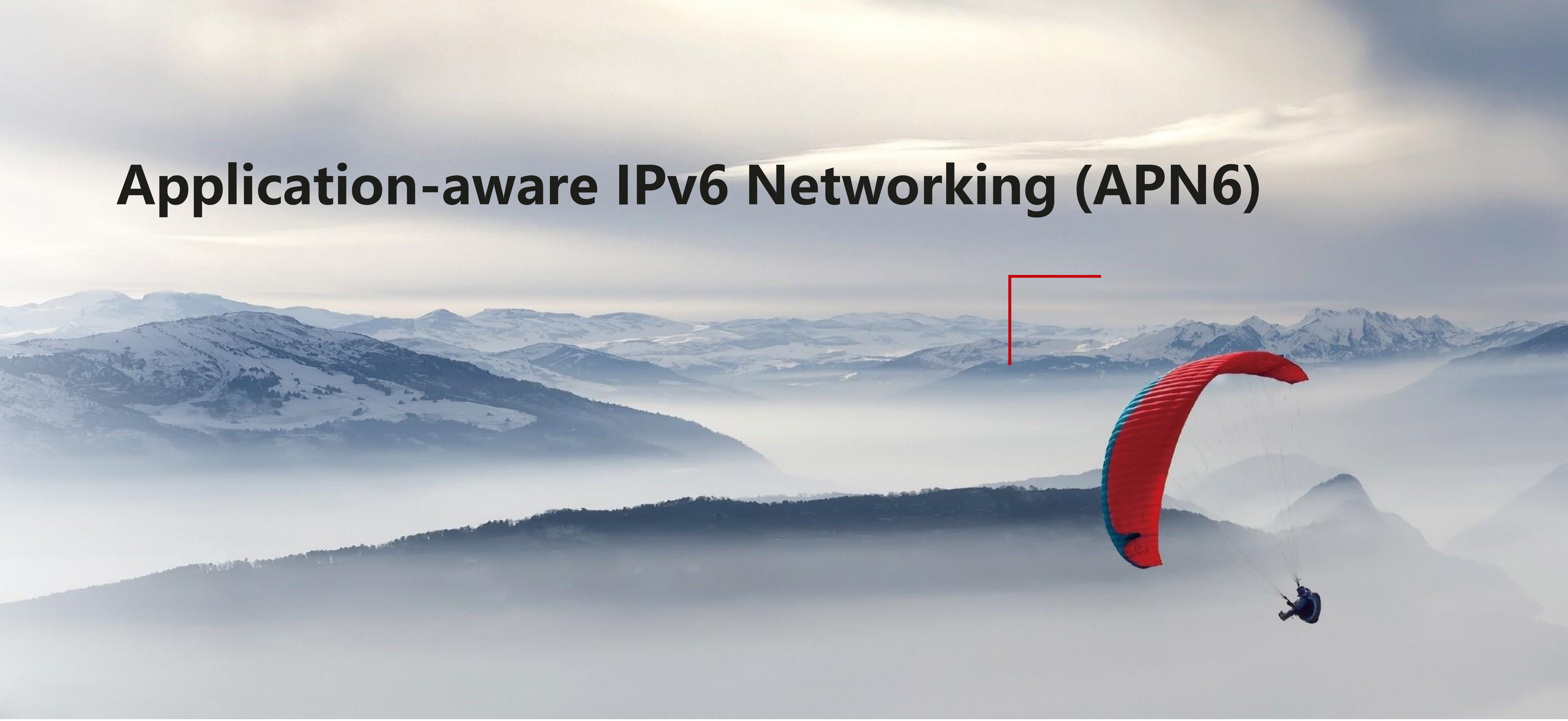
IETF

MPLS SD & AI NET VIRTUAL 21

22ND EDITION 28/30 SEPT

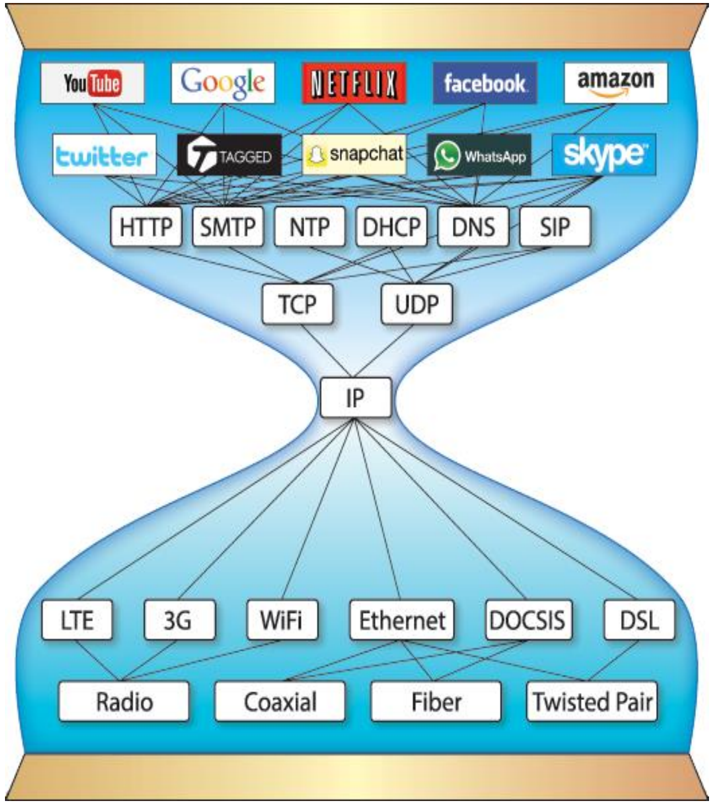


Application-aware IPv6 Networking (APN6)

Security Level:

Challenges of Carrier's Service

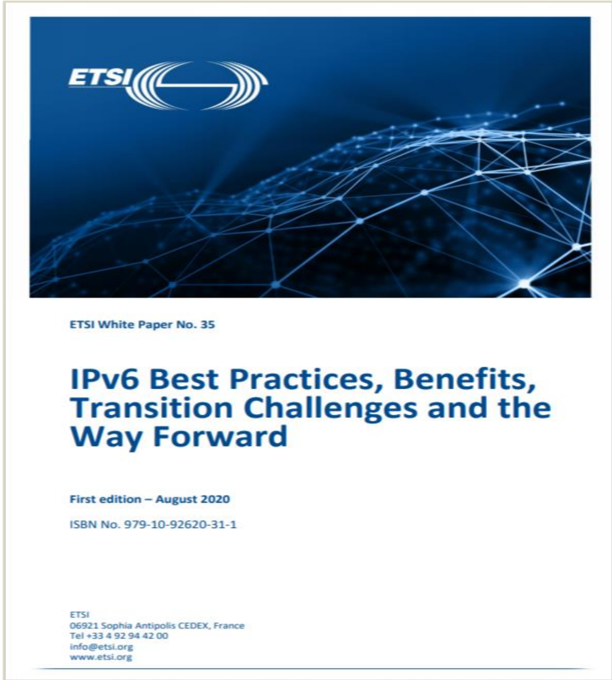
- Bottleneck for Transport Networks of Operators: Pipe only
  - BW requirement increasing greatly
  - Less revenue from the network service
- Bottleneck for Transport Networks of Operators: Networking on its own – Repeated VPN/TE/FRR work



Gap Analysis of Fine-grain Services

- Challenges of value-added services based on the existing application-aware methods
    - 5 Tuples using for ACL/PBR
        - Indirect application info which is in need of transition
        - Forwarding performance issues
        - Scalability issues come from the limitation of hardware resource
    - DPI (Deep Packet Inspection)
        - Challenges from network neutrality
        - Challenges from network security
        - Forwarding performance issues
    - Orchestrator and SDN
        - Complex interaction
        - Too many interfaces to be standardized

IPv6 Enhanced Innovation to Meet the New Requirements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IPv6 Best Practices, Benefits, Transition Challenges and the Way Forward

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10 co-author companies

5 operators provide review

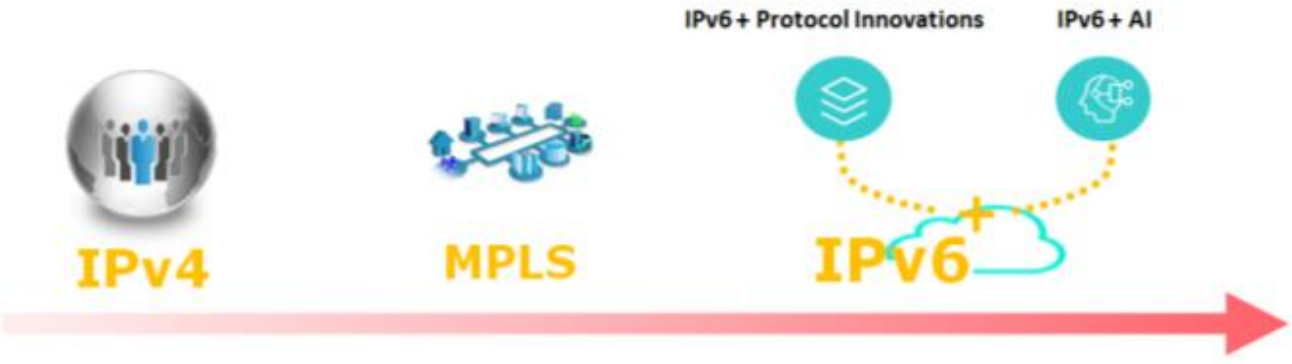


Figure 18: IPv6 enhanced innovation promoting the development of network

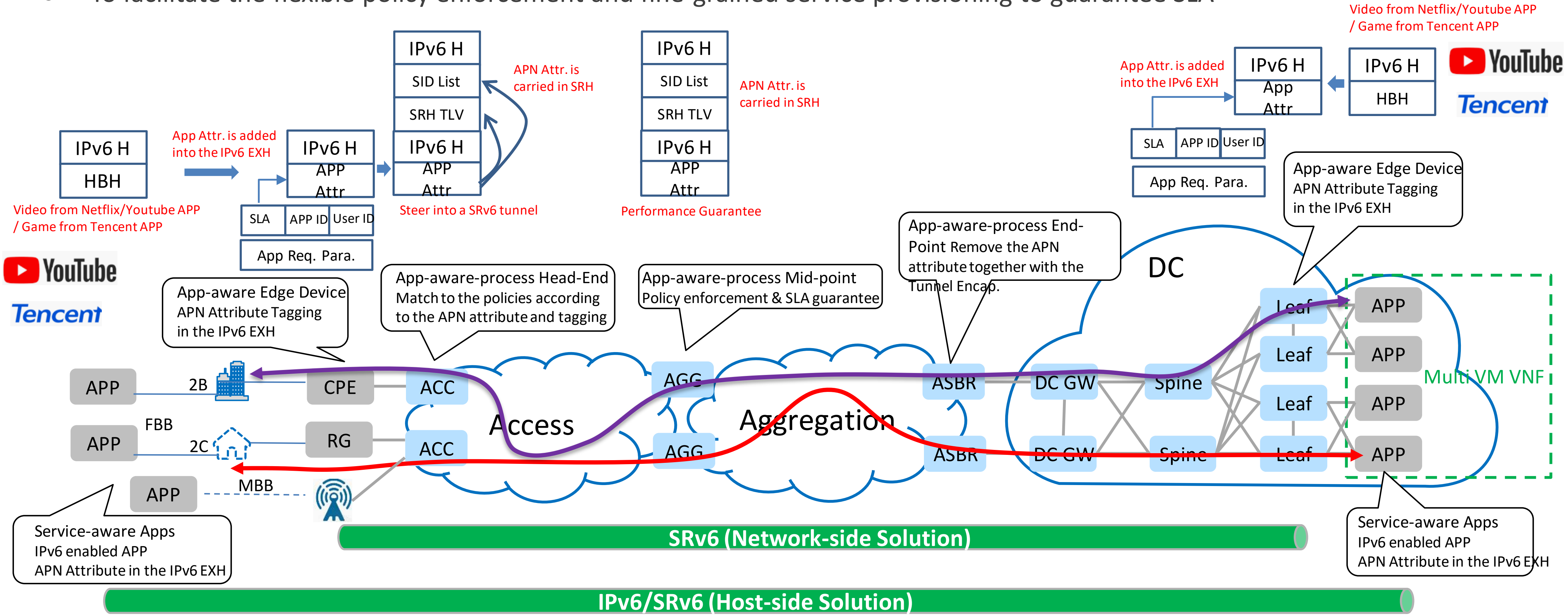
The development of network has gone through phases for the requirements of different eras. To meet the new requirements brought by 5G and cloud, IPv6 based protocol innovation (IPv6 + protocol innovation) and IPv6 adding AI (IPv6+AI) , are IPv6 enhanced innovations, which can be abbreviated as "IPv6 +", represented by protocols innovations such as SRv6, etc., combined with network analysis, intelligent tuning, and other network intelligent innovation technologies, to realize intelligent path planning, service speed opening, operation and maintenance automation, quality visualization, SLA assurance, application perception, etc.

Published in Aug 2020

https://www.etsi.org/images/files/ETSIWhitePapers/etsi_WP35_IPv6_Best_Practices_Benefits_Transition_Challenges_and_the_Way_Forward.pdf

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 to guarantee SLA

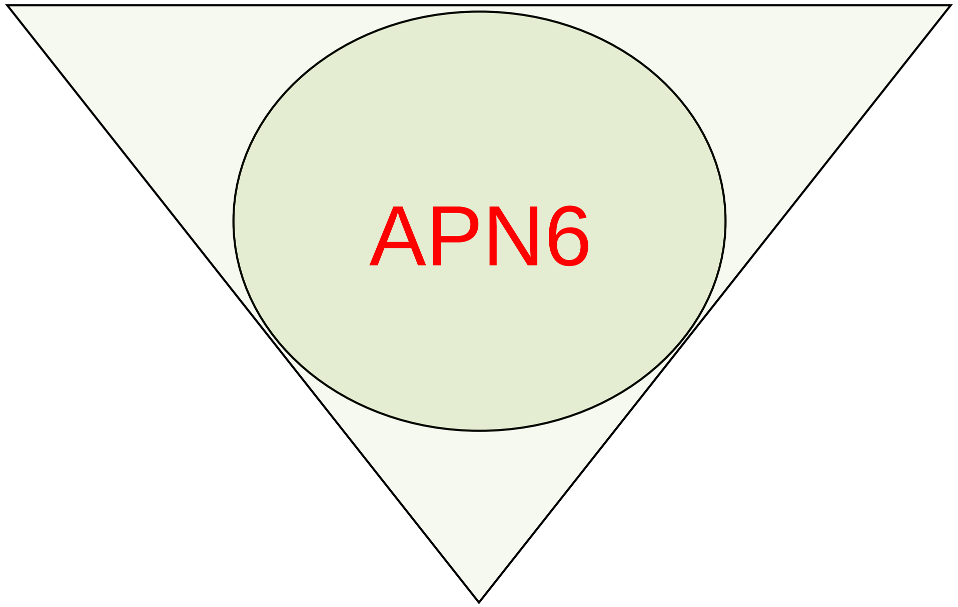


https://datatracker.ietf.org/doc/draft-li-apn-framework/
https://ieeexplore.ieee.org/abstract/document/9162934

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



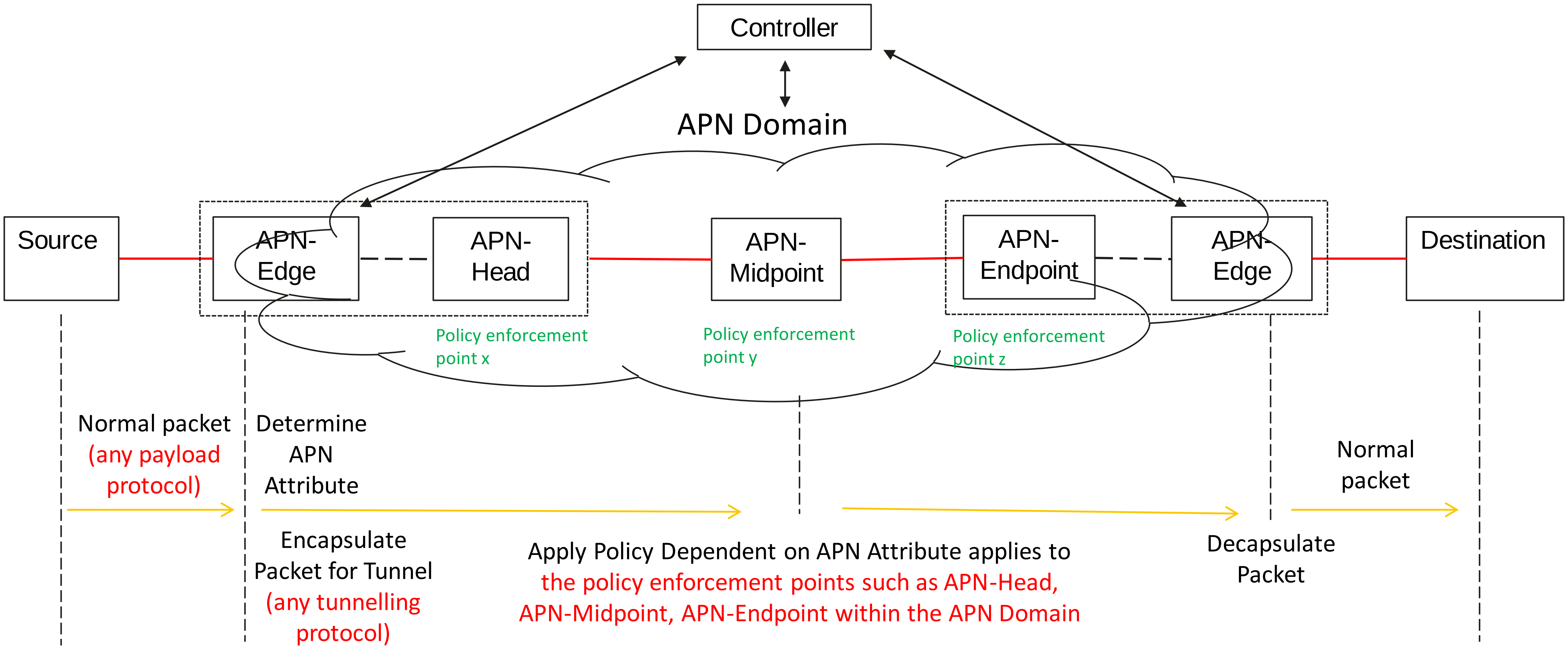
2. Rich network services

- 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.

Reference Diagram of APN Network-side Solution



An APN Domain may span multiple network domains controlled by the same operator

What is APN (Application-Aware Networking)?

- Application-aware Networking (APN) is a new framework, where
  - the APN attribute including APN identification (ID) and/or APN parameters (e.g. network performance requirements) is encapsulated at network edge devices
  - the APN attribute is carried along with the tunnel encapsulation for the packet traversing an APN domain

- APN attribute makes the traffic flow being treated as an object in the network
  - To it, the network operator applies policies in various nodes/service functions along the path and provides corresponding services.

- APN aims to apply various policies in different nodes along a network path onto a traffic flow altogether, e.g.
  - at the headend to steer into corresponding path
  - at the midpoint to collect corresponding performance measurement data
  - at the service function to execute particular policies

The Goal of APN

1. The APN attribute allows the network devices to only look at one easily-accessible field in the tunnel header
   - 5 tuples vs. 1 tuple
   - Not having to resolve the 5 tuples of the original packets that are deeply encapsulated in the tunnel encapsulation

2. The APN attribute allows to simplify the policy control at every policy enforcement point within the network
   - The APN attribute allows to reducing each matching entry of policy filter since it is only one field and hardware resources are saved
   - Since APN attribute is relatively stable it introduces the possibilities of eliminating the “stale” policy filter entries
   - In most cases, the APN attribute is centralized configured and distributed to all the policy enforcement points, which saves the policy filter configurations per node and simplifies the O&M

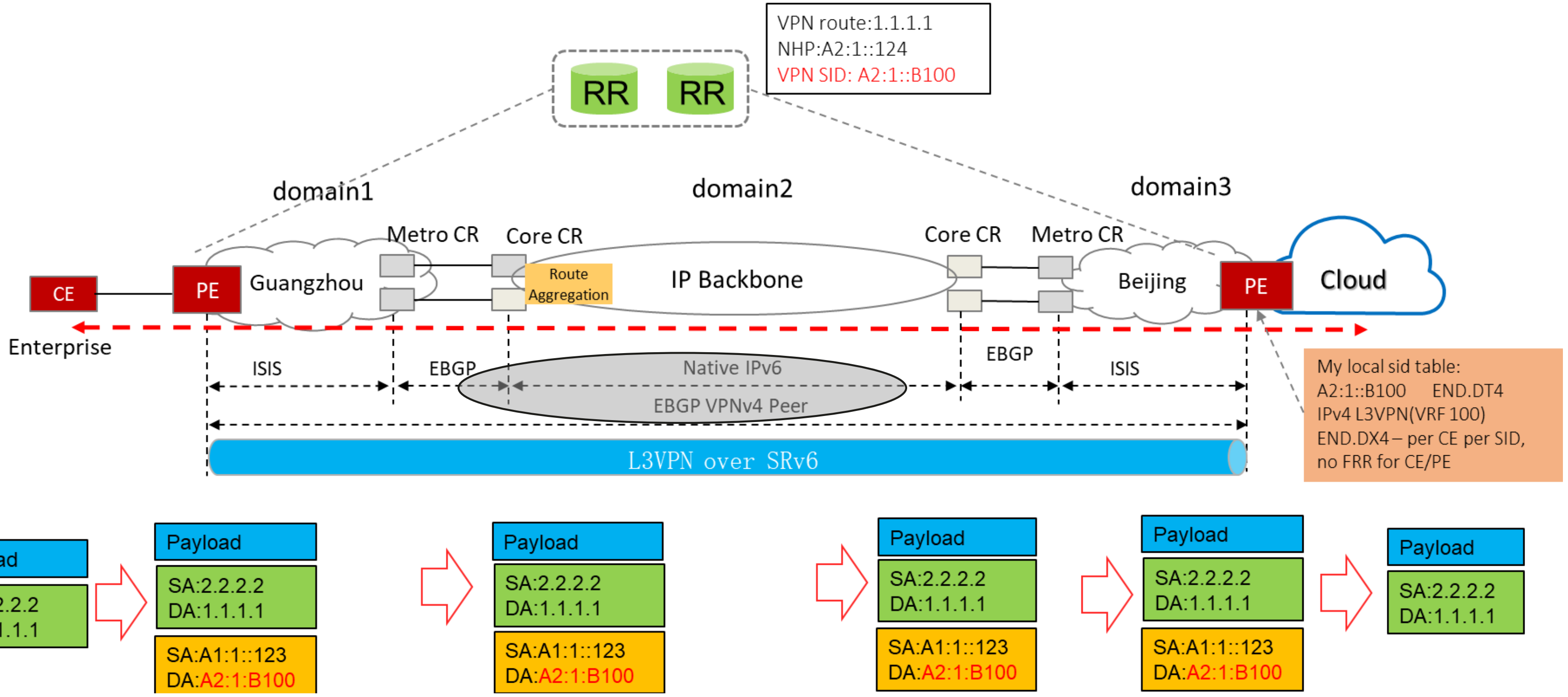
3. The structured APN attribute allows to express fine granular service requirements
   - e.g. MKT-user-group/app-group, R&D-user-group/app-group, latency

4. The structured APN attribute allows to match to the evolving fine granular differentiated network capabilities
   - e.g. SR policy with low latency and high reliability guaranteed

Use Case Example: SRv6-based Cloud Lease Line Service

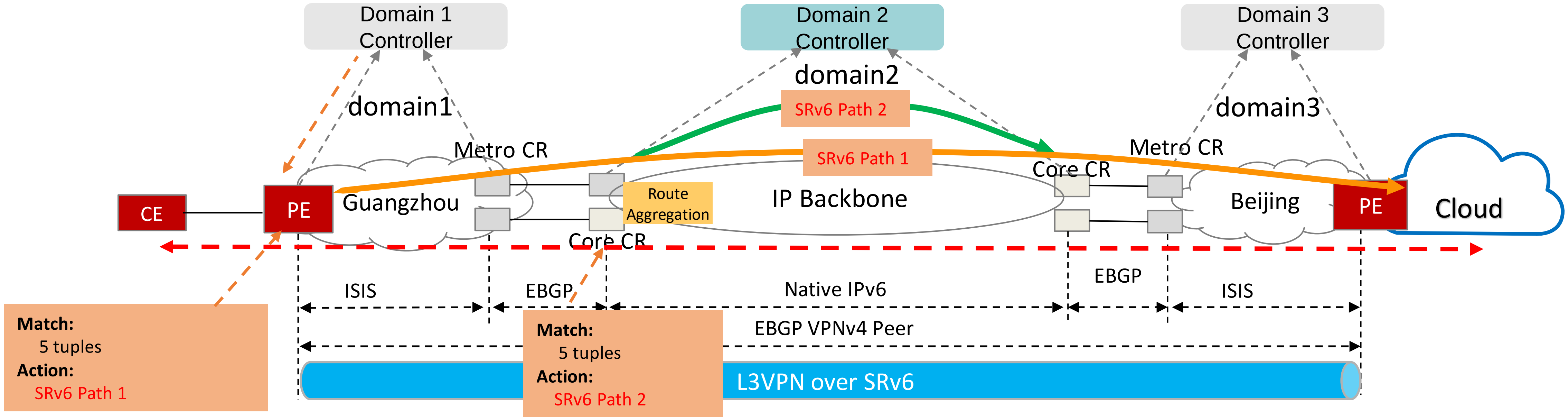
- Take the “SRv6-based Cloud lease Line Service” as **an illustrative example** to show how APN is needed and can be beneficial
- Enterprises usually buy “SRv6-based Cloud lease Line Service” to interconnect their local sites to Cloud
- The “SRv6-based Cloud lease Line Service” usually needs to go **across multiple domains**, which are **owned by one operator** and controlled by multiple controllers and an orchestrator/super-controller.
- Due to management and **security** reasons, the network information in the intermediate domain cannot be advertised to other domains, so the ingress node cannot set up an appropriate E2E path
  - ✓ **the intermediate domain** is treated as a black box and **no fine grain traffic steering and other services**

SRv6-based Cloud Lease Line Service



Traffic Steering in the IP Backbone – No APN

- Issues:
  - Due to management and security reasons, the network information in the intermediate domain cannot be advertised to other domains
    - the ingress node can not set up an appropriate E2E path, the intermediate domain is treated as a black box and no fine-granular traffic steering
  - The traffic steering policy in the intermediate domain/IP backbone can only be set up based on the 5-tuple of the inner packets at the route aggregation node (core CR), wherein the 5-tuple has to be resolved and this is very “expensive”



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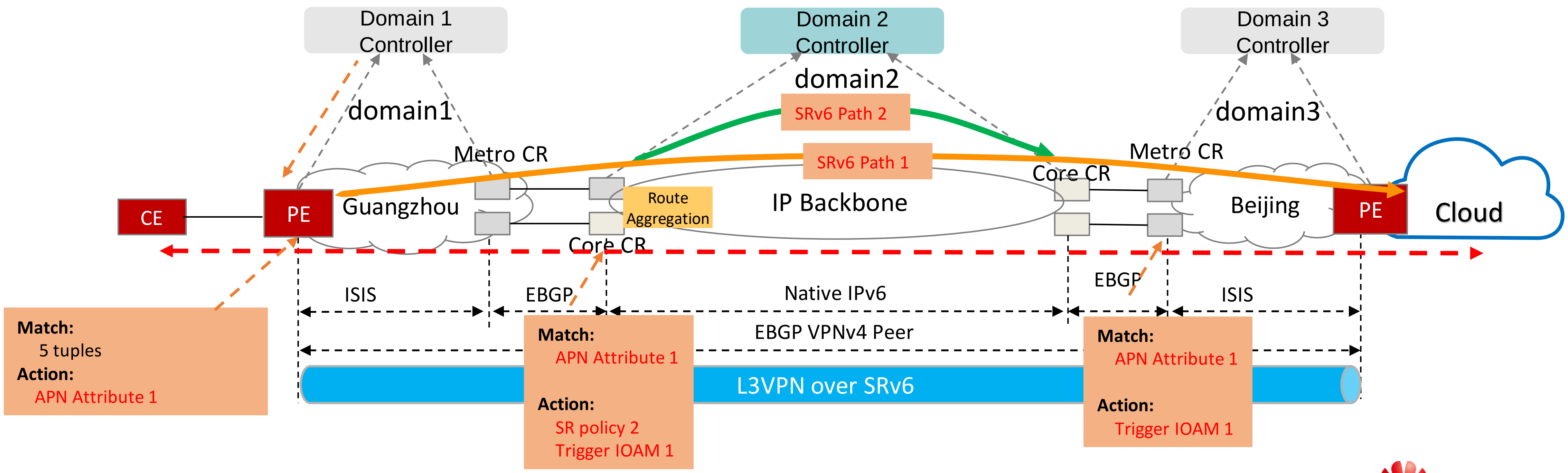
Traffic Steering in the IP Backbone – With APN

- With APN:
  - APN attribute is encapsulated at the ingress node.
  - With the APN attribute, the fine-granular traffic steering in the IP backbone can be easily facilitated.
    - To match some field(s) of the APN attribute, a path with low-latency can be selected and steered into.
  - Other policy actions (such as IOAM) can also be triggered according to the APN attribute carried in the header.

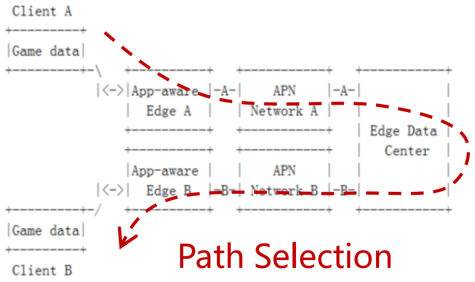


APN Use Case I

Cloud Gaming

Requirements:

- High bandwidth for the game video data
- Low latency for the interaction
- **Service consistency among multi-users**



Edge computing can reduce the overall latency of service and reduce the demand for network bandwidth , and APN can achieve:

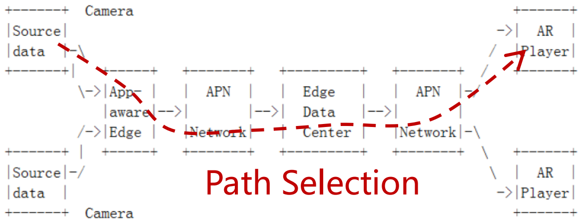
* Multiple edge devices obtain and encapsulate application feature information and send it to the head end node.
* Head end/edge node identifies the data flow, and steers it into a specific transmission path, which needs to **ensure that the latency of multi-user control instructions arriving at the edge data center is consistent**.
* Mid point forwards data stream according to the predetermined path.
* The end point receives the data stream and steers it either to the data center for processing the users' control instruction or to the user for playing.

draft-liu-apn-edge-usecase

Augmented Reality (AR)

Requirements:

- High bandwidth for the collected video source data
- Low latency for the User experience



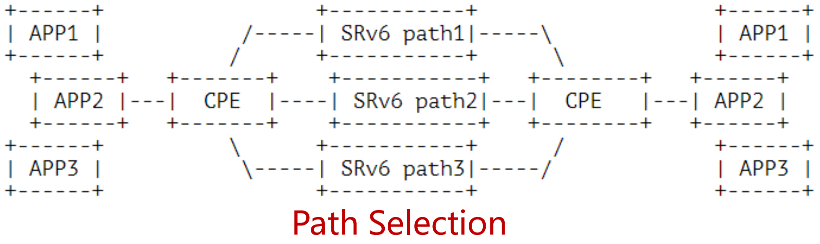
Edge computing can reduce the overall latency of service and reduce the demand for network bandwidth , and APN can achieve:

* Edge device obtains and encapsulates AR application feature information
* Head end/edge node identifies the AR data flow and steers it into a specific transmission path.
* Mid point forwards the data stream along the specific path.
* End point receives AR data stream and forwards it either to Data Centre for processing or to the AR player for playing.

https://github.com/APN-Community/IETF108-Side-Meeting-APN

APN with SRv6

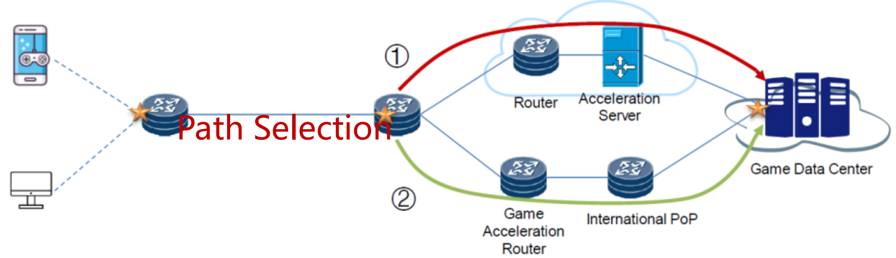
By carrying the application identification and demand information through data packets, i.e., the delivery of application information and ensuring the security and reliability of application information, the network senses the application and provides it with high-quality differentiated services according to the demand of the application. And when the network transmits the data packets, it matches the network correspondence policy according to the application information in the data packets and selects the corresponding SRv6 path to transmit the data packets (e.g., low latency path) to meet the SLA requirements and service chain in order to improve the service quality.



SRv6 enabled SD-WAN

draft-yang-apn-sd-wan-usecase

APN for Steering into Dedicated Game Acceleration Channel



draft-zhang-apn-game-acceleration-usecase

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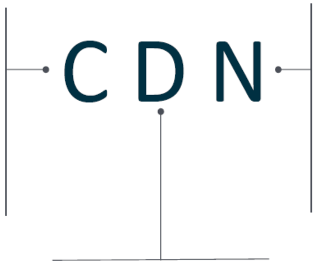
APN Use cases II

APN-aware networking

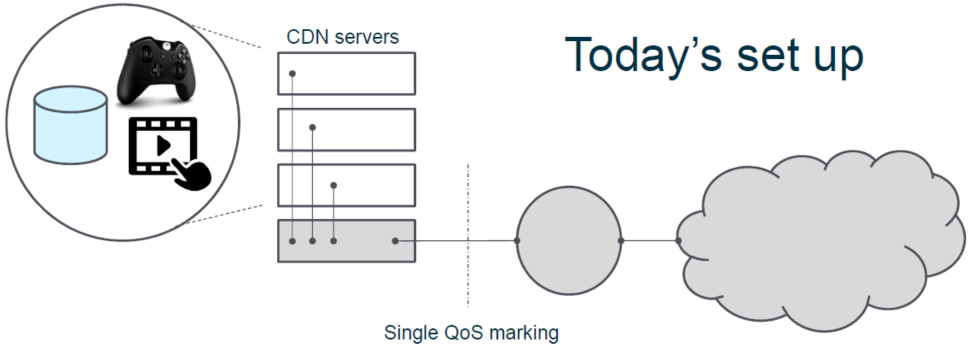
Content
Different kinds of contents addressing different types of services become distributed from CDNs: streaming videos, large files, software upgrades, VR/AR, gaming, etc. Those services present different characteristics (i.e., SLOs)



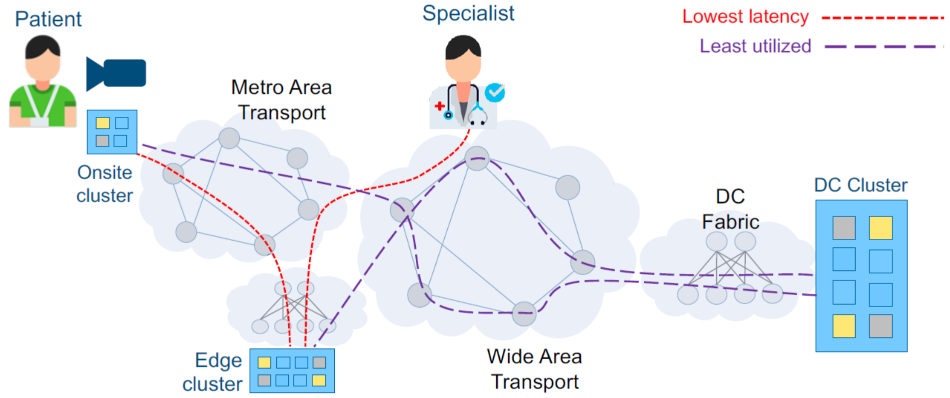
Network
Homogeneous behavior should be expected independently of the node that injects the traffic, and the content provider who injects such traffic

Delivery
Today uniform treatment of CDN traffic, since the Network is unable to get / capture finer details of the transported traffic

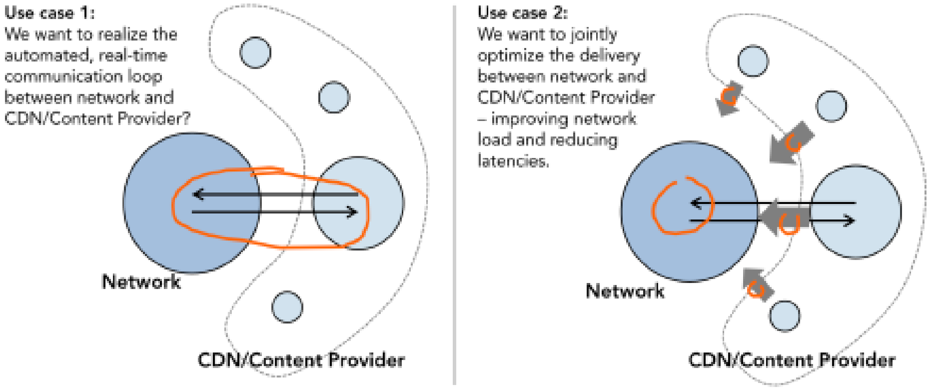
Today's set up



- Additional information from application (e.g., performance requirements) could be beneficial for assuring service delivery from network perspective
- Information originated by the application, not inferred by the Network by any means



Use cases description:



https://github.com/APN-Community/IETF108-Side-Meeting-APN

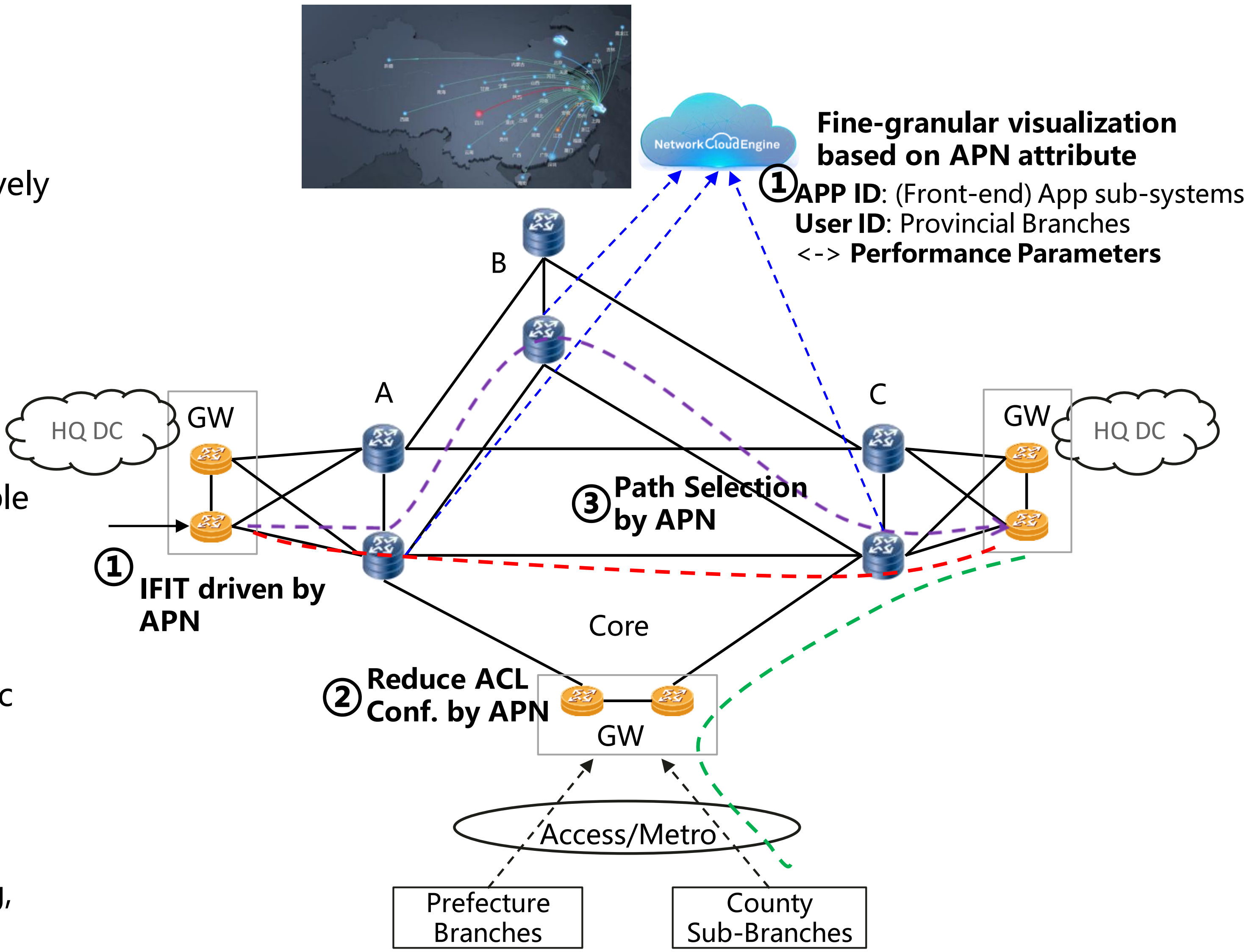
APN Use cases III

APN enables, in the Financial service field,

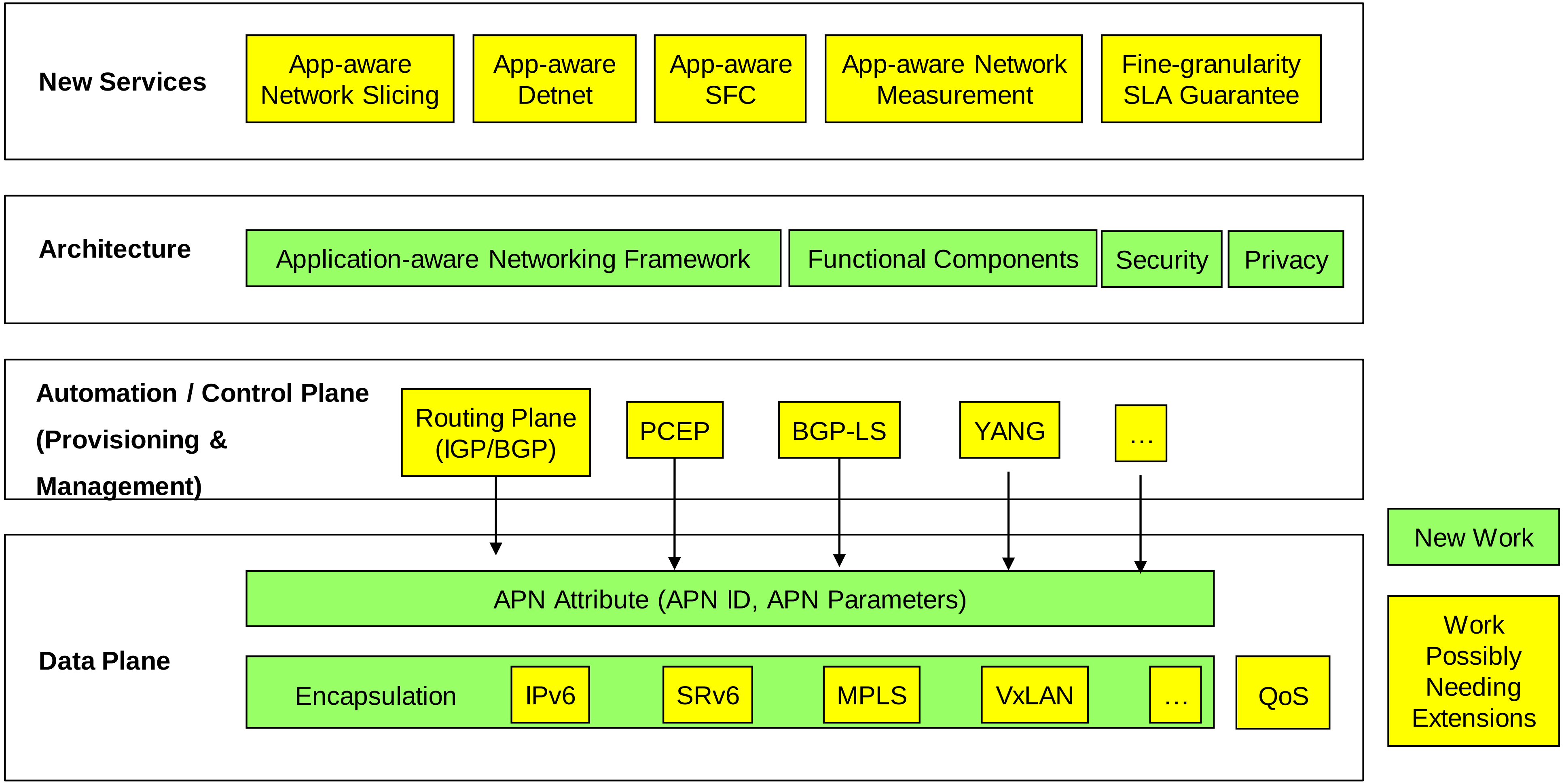
- ✓ Application visualization and Differentiated service provisioning
- ✓ ACL maintenance simplification due to relatively stable APN ID
  - ✓ Centralized configuration, once for all
- ✓ Path selection to satisfy services' SLA requirements

APN takes advantage of the native programmable space provided by IPv6 to carry application/user group information and requirements (i.e. **APN Attribute**),

- ➢ making **network aware of** key valuable traffic flows
- ➢ enabling **fine-grained network service provisioning** such as **visualization**, **performance measurement**, **traffic steering**, **dynamic scheduling and adjustment**, etc..



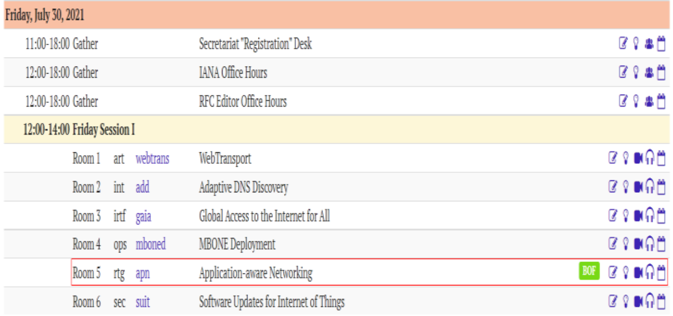
Potential Work Items to be covered



APN Activities I

- **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

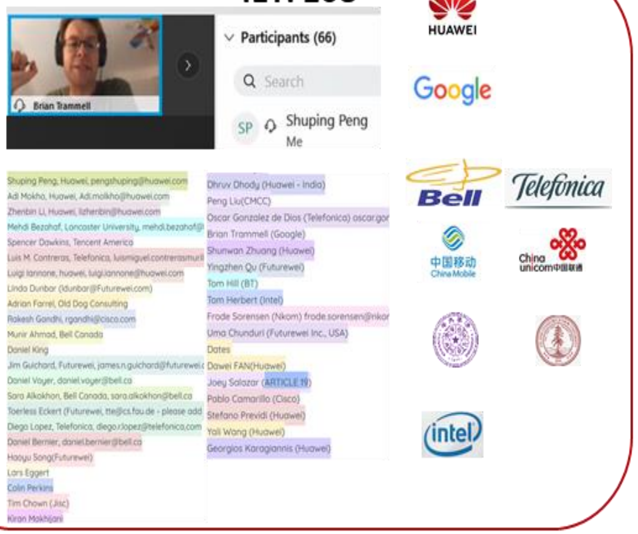
IETF111 APN BoF



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



IETF109

IETF110

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)

APN Activities II

- **Side Meetings** @IETF105 & IETF108
- **Hackathons** @IETF108 & IETF109 & IETF110
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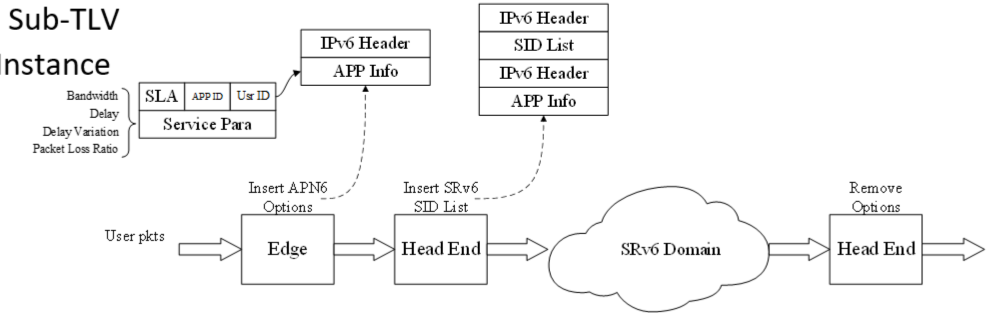
- Application-aware traffic control.
  - Make use of the IPv6 extensions header to convey the service requirements, in the form of APN6 options and optional Sub-TLV.
  - Determine the SRv6 SID List based on the encapsulated options and Sub-TLV
- An Instance



https://trac.ietf.org/trac/ietf/meeting/wiki/110hackathon
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https://trac.ietf.org/trac/ietf/meeting/wiki/108hackathon

Application-aware G-SRv6 network

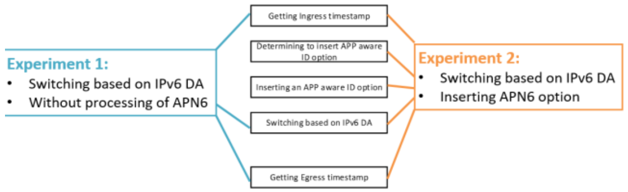
- Champions
  - Jianwei Mao (maojianwei@...)
  - Cheng Li (c.l@...)
  - Shuping Peng (pengshuping@...)
- Projects
  - Develop functions of Generalized SRv6 (G-SRv6).
  - Combine G-SRv6 with APN6, to achieve Application-aware G-SRv6 network.
- Specifications
  - draft-lc-6man-generalized-srh
  - draft-cl-spring-generalized-srv6-np
  - draft-cl-spring-generalized-srv6-for-cmpr
  - draft-li-6man-app-aware-ipv6-network
  - draft-li-apn-framework

Implemented Functions

- We've implemented the demo based on *P4*, and conducted some simulations based on *BMv2*.
- Functions in Demo
  - APN6:
    1. The encapsulation of APN6 Options and Serice-Para Sub-TLV, support 2 types of APN6 Options and 4 types of Sub-TLV
    2. The encapsulation of the SRv6 SID List according to IPv6 DA and APN6 options
    3. Basic SRv6 END SID processing

Performance Evaluation

- **Processing Latency**



- **Result**
  - Send 50,000 packets in each experiment.
  - The interval between 2 packets is 1ms.
  - All results are in nanoseconds

Experiment	*Mean*	*STDEV*	*MAX*	*MIN*	*Range*
1 (IPv6)	364.07436	0.56514087	366	363	3
2 (IPv6 & APN6)	370.63256	0.611774343	373	369	4
DIFF	6.5582	0.046633473	7	6	

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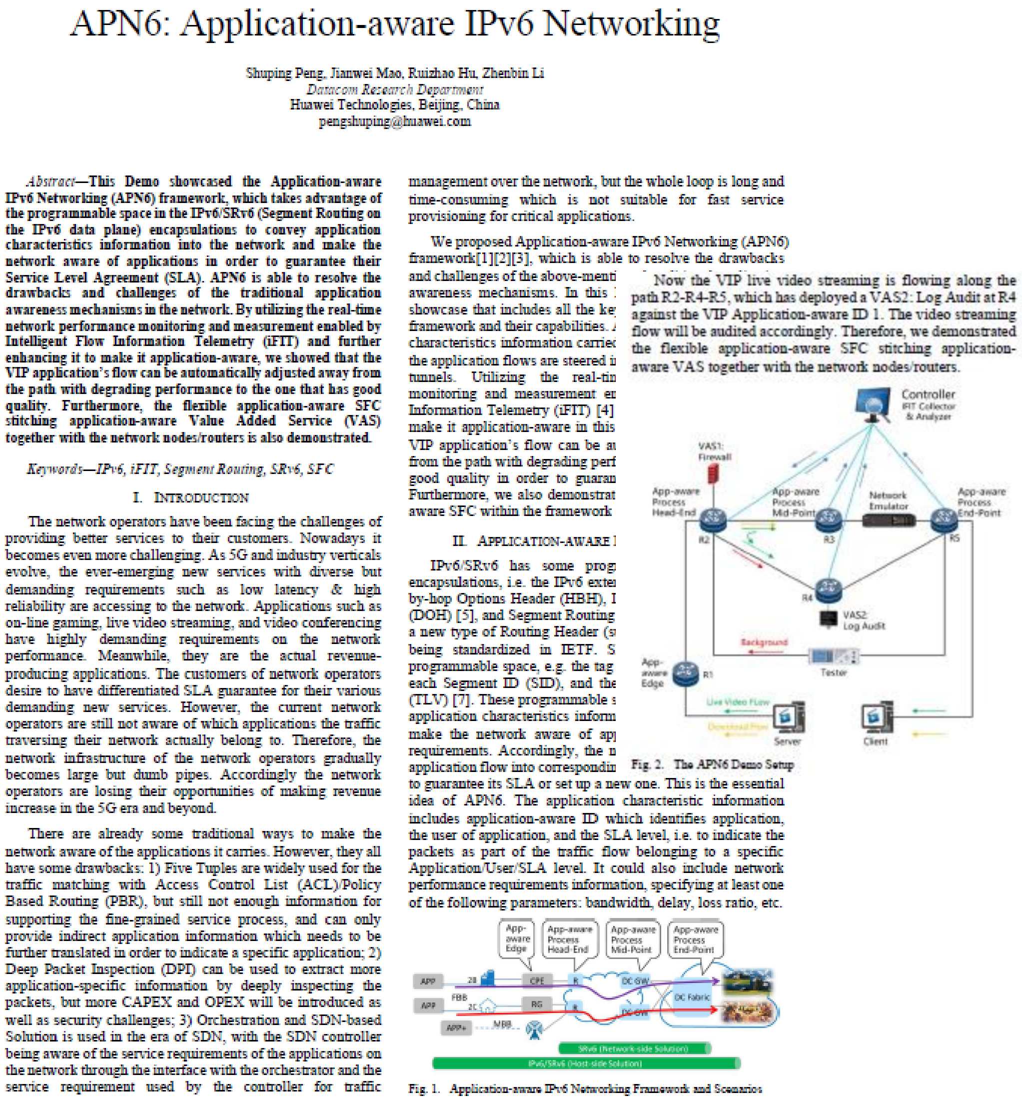
APN Activities III



APN6: Application-aware IPv6 Networking

Shuping Peng, Jianwei Mao, Ruizhao Hu, Zhenbin Li
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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-menti… 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 e… 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 …

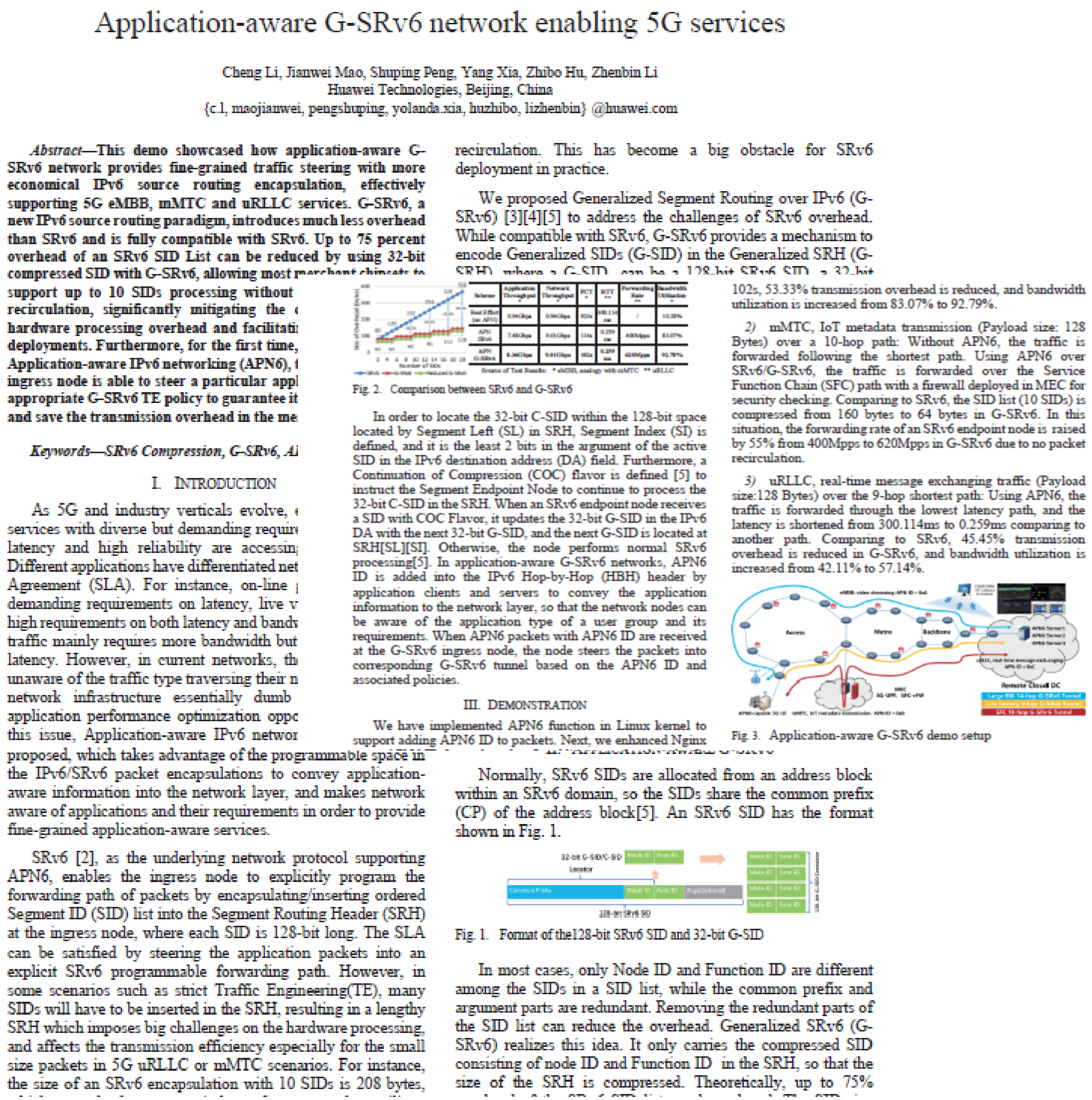
II. Application-aware I…

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 … 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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{c.l, maojianwei, pengshuping, yolanda.xia, huzhibo, lizhenbin} @huawei.com

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 … hardware processing overhead and facilitati… deployments. Furthermore, for the first time, … Application-aware IPv6 networking (APN6), … 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 accessin… Different applications have differentiated net… Agreement (SLA). For instance, on-line … demanding requirements on latency, live v… high requirements on both latency and bandv… 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) …

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 the128-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

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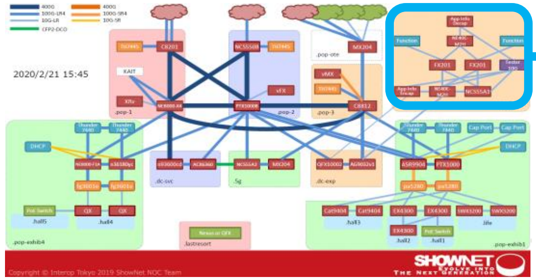

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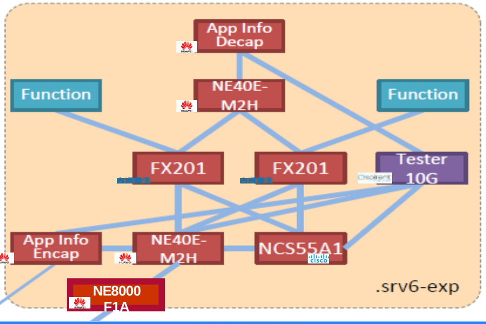

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IETF 105 Montreal
20 Jul 2019 - 26 Jul 2019
APN6 Side Meeting
2019.7

IETF 106 Singapore
16 Nov 2019 - 22 Nov 2019
F2F meeting with Shownet NOC team
2019.11

APN POC Collaboration
2019.12

SHOWNET EVOLVE INTO THE NEXT GENERATION
APN Shownet Setup Plan
2020.1

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