Application-aware G-SRv6 network enabling 5G services

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Introduction

Cheng Li

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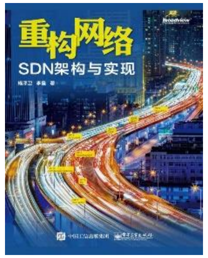

- 30+ IETF drafts， 10 + WG drafts，1 RFC
- Currently focus on G-SRv6/SRv6，SFC，OAM
- Author of books
  - “ SRv6 Network Programming - Ushering in a New Era of IP Networks ”
  - “ Refactoring Network: Architecture and Implementation of SDN ”
- Paper : “ Application-aware G-SRv6 network enabling 5G services ” , INFOCOM 2021

Jianwei Mao

Huawei IP Senior Engineer for Research

- Currently focus on CFN，G-SRv6/SRv6，APN6
- Author of books
  - “ SRv6 Network Programming - Ushering in a New Era of IP Networks ”
- Paper
  - “ APN6 : Application-aware IPv6 Networking ” , INFOCOM 2020
  - “ Application-aware G-SRv6 network enabling 5G services ” , INFOCOM 2021
  - “ CFN-dyncast : Load Balancing the Edges via the Network ” , IEEE WCNC 2021

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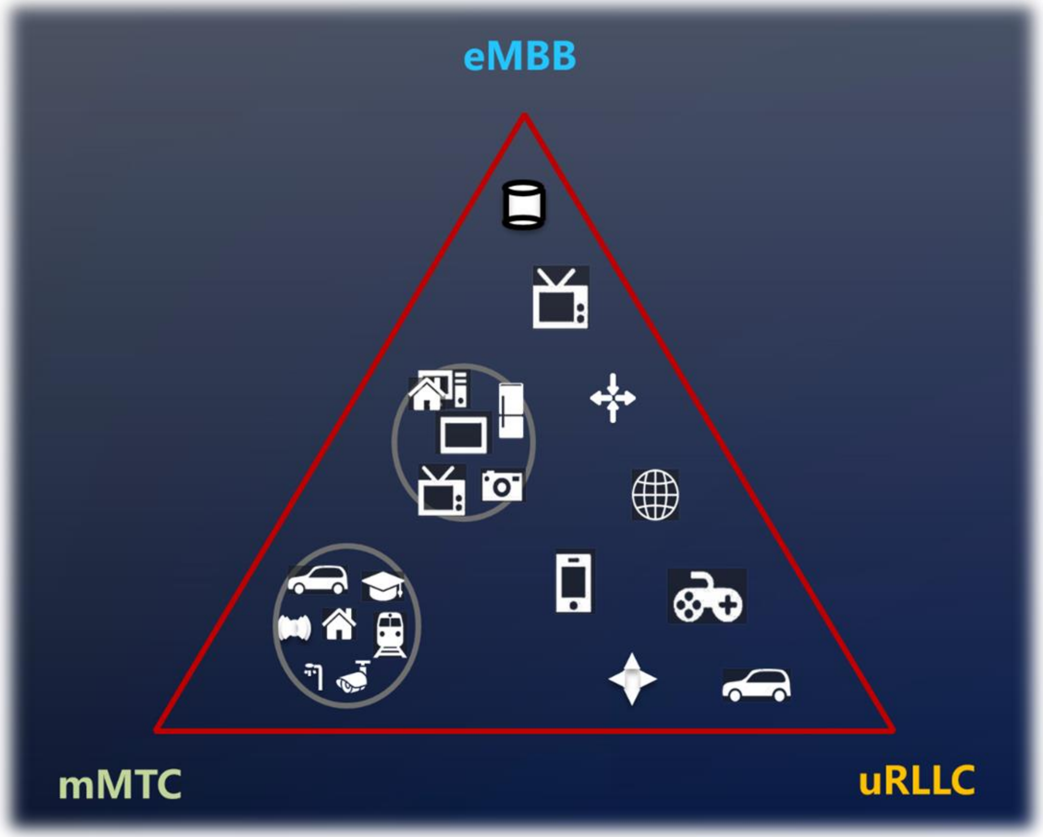
Motivation 1: New 5G services with differentiated SLA

As 5G and industry verticals evolve, ever-emerging new services with diverse but demanding requirements.



Example

- On-line gaming
  - highly demanding requirements on latency
- Live video streaming
  - latency and bandwidth
- Backup traffic
  - more bandwidth but less sensitive of latency

However

Unaware of the traffic type now

→ Dumb pipes

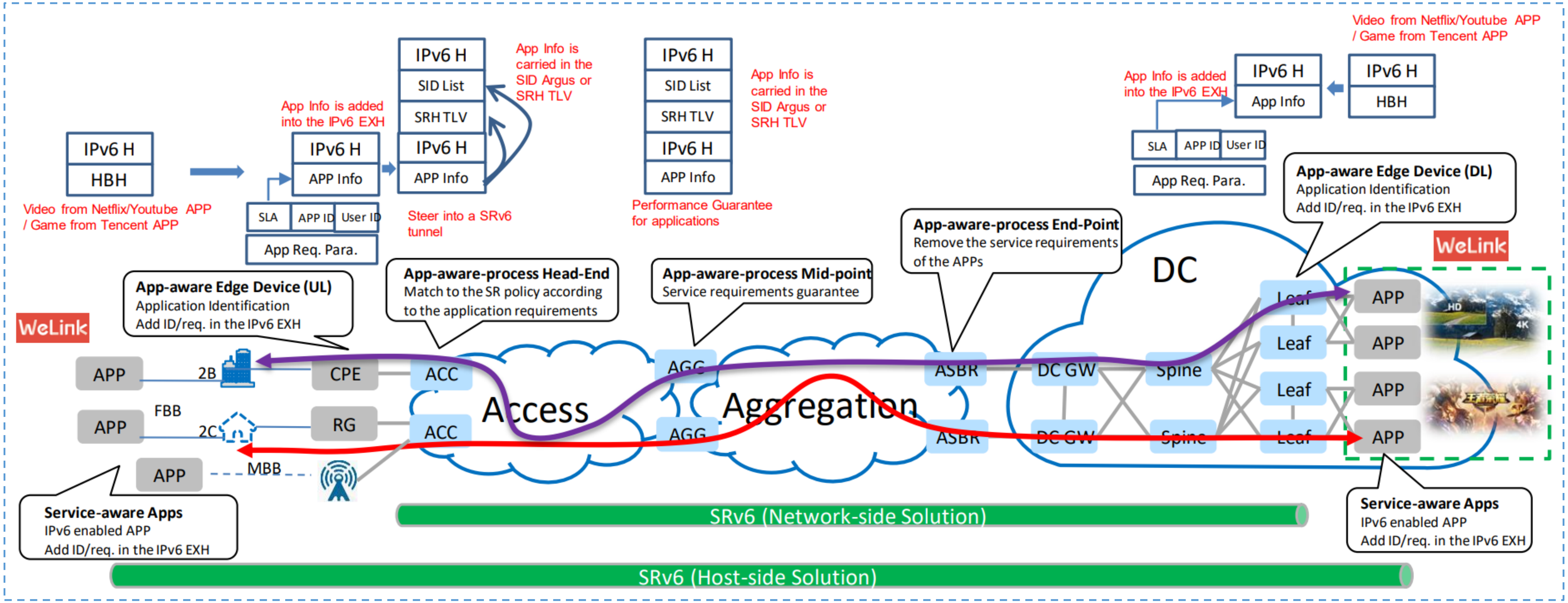
→ Lose opportunities to optimize application performance

Remind: Application-aware IPv6 Networking (APN6)

Take advantage of the programmable space in the IPv6/SRv6 encapsulations

→ Convey application characteristics information into the network

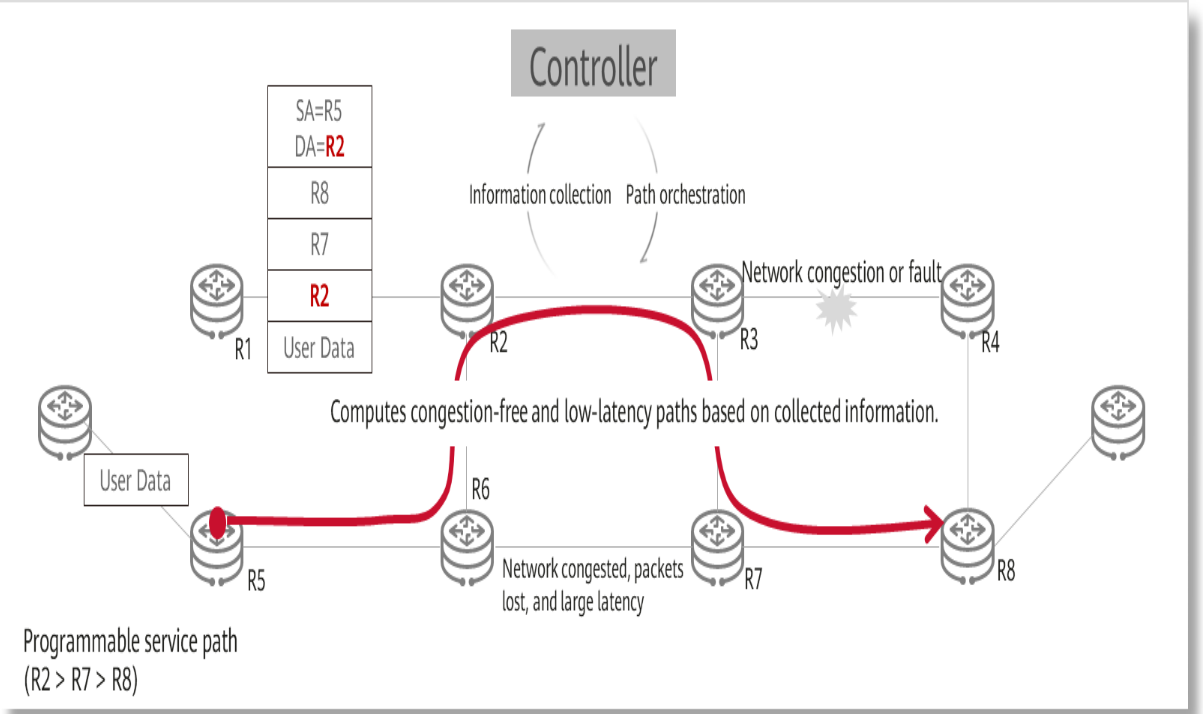
→ Make the network aware of applications in order to guarantee their Service Level Agreement (SLA)



Motivation 2: SRv6

SRv6 enables the ingress node to explicitly program the forwarding path of packets, by adding SIDs into SRH.

The SLA can be satisfied by steering the application packets into an explicit SRv6 programmable forwarding path.



Version	Traffic Class	Flow Label		IPv6 Header
Payload Length		Next Header=43	Hop Limit	
Source Address				
Destination Address				
Next Header	Hdr Ext Len	Routing Type	Segments Left	
Last Entry	Flags	Tag		
Segment List[0]				SID List
Segment List[1]				
Segment List[2]				
Segment List[3]				
Segment List[4]				
Segment List[5]				
Segment List[...]				
Segment List[N]				

IPv6 packet carrying an Segment Routing Header (SRH)

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Motivation 2: Transmission overhead of SRv6

However, the size of SID list is too large for the packets of 5G services: 160 bytes needed by 10-hop tunnels.

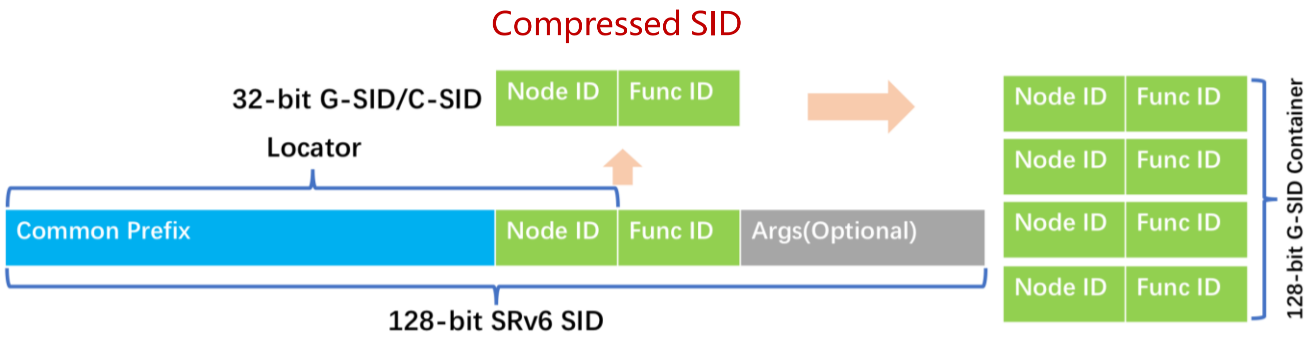
5G Services / Scenarios	with SRv6

• eMBB
  • High bandwidth, large packets(>1024 bytes)
  • File downloading, live streaming …
	• eMBB
	  • 1024 bytes → 1232 bytes
	  • **+20%** packet size

• mMTC
  • Low latency, small packets(~128 bytes)
  • IoT metadata, Industrial internet …
	• mMTC / uRLLC
	  • 128 bytes → 336 bytes
	  • **+162%** packet size

• uRLLC
  • Low latency, small packets(~128 bytes)
  • On-line gaming, V2X …
	Transmission overhead is too high to support 5G.

Solution： Generalized Segment Routing over IPv6 (G-SRv6)



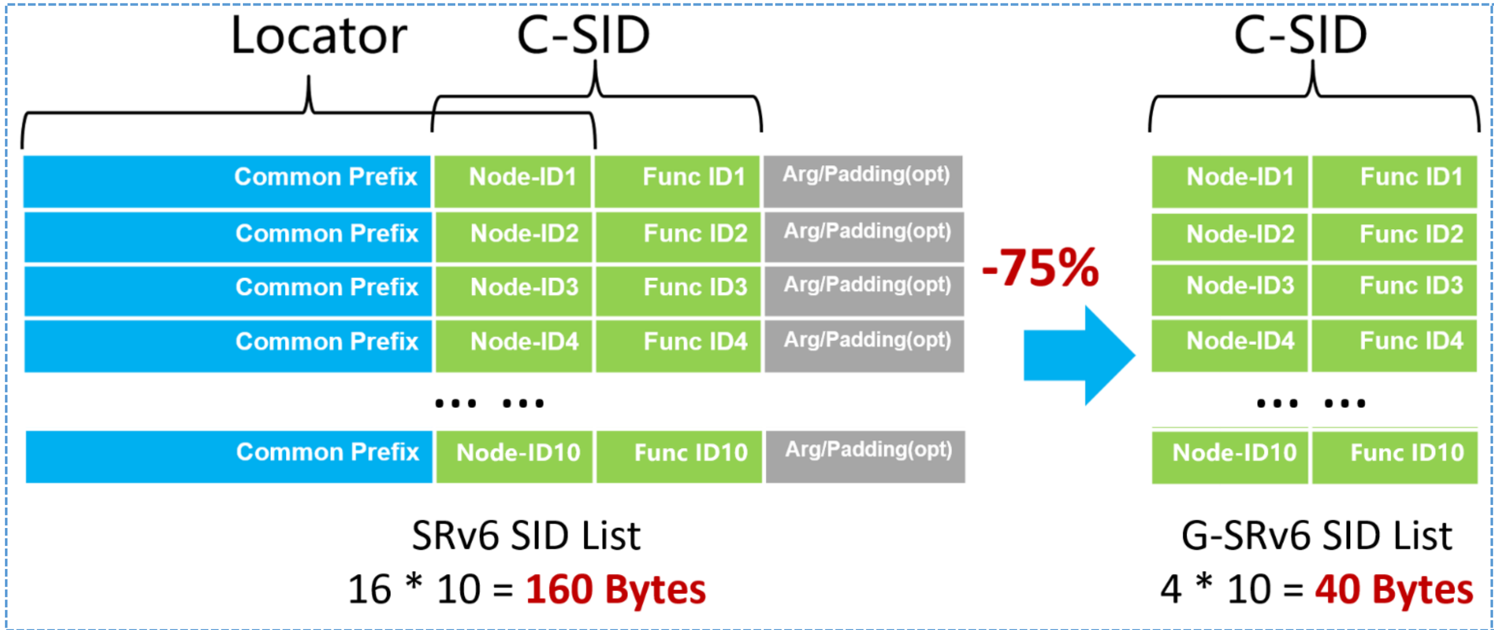
For 128-bit SRv6 SID：

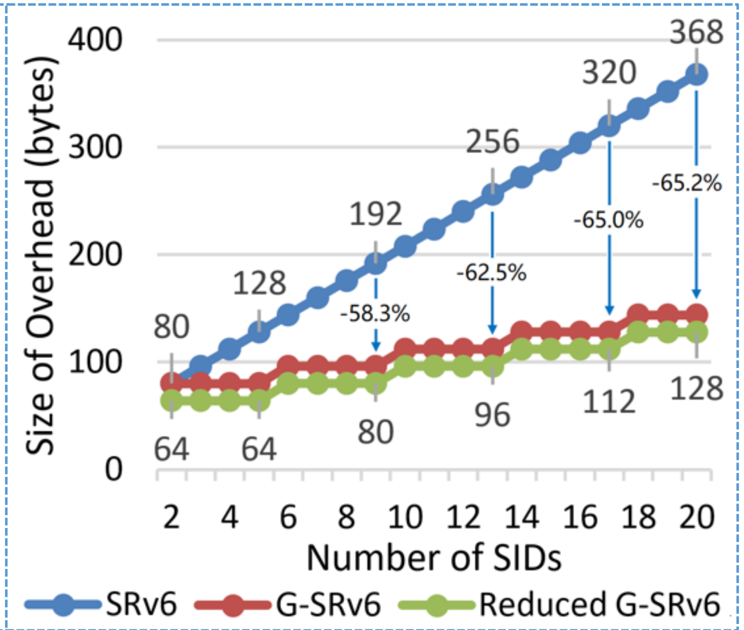
- Only Node ID and Function ID are different among the SIDs in a SID list.
- Common prefix and argument parts are redundant.

As for network planning, 32-bit is the ideal length for the Compressed SID.

12+ Vendors have PASSED Interop-test

Solution：Generalized SRv6 Network Programming (G-SRv6)





- Reduce 75% size of SID List (transmission overhead).
- No new IPv6 address consumption, no new route creation.
- Fully compatible with SRv6, incremental deployment, deploy on demand.

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Further: Application-aware G-SRv6 network, enabling 5G services

- Enable application-aware fine-grained strict TE, with lower transmission overhead.

- Application-aware control
- Based on service requirements

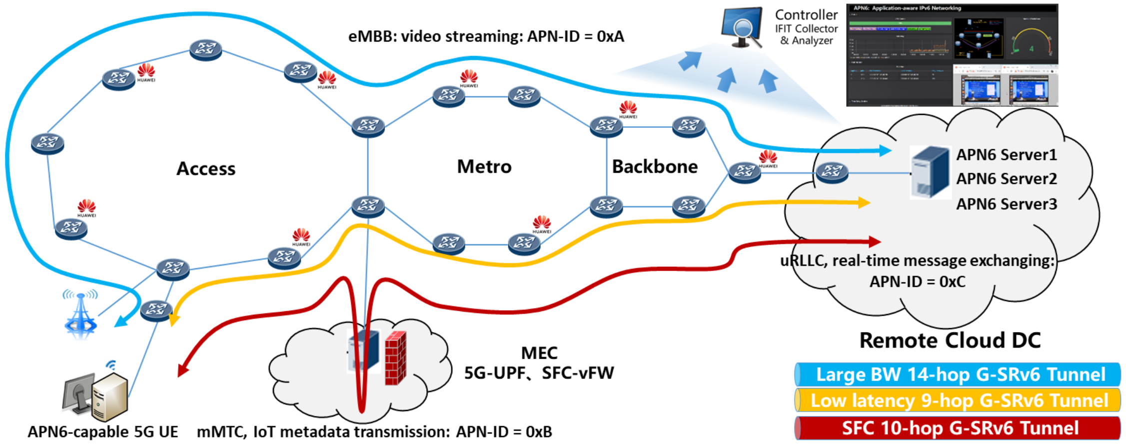
APN6 + **G-SRv6** → **Application-aware G-SRv6 networking**

- More efficient encapsulation
- SLA-guaranteed transmission resources
- Network programmability, fully compatible with SRv6

Demo：Application-aware G-SRv6 network, enabling 5G services

- We’ve implemented the demo based on *Linux Kernel* & *Huawei Router.*
- Functions in our demo:
  - APN6:
    1. Encapsulate APN6 Options in IPv6 Hop-by-Hop Options Header, with application-specific info.
  - G-SRv6:
    1. Identify APN6 info, and select the most suitable G-SRv6 TE tunnel for the specific App / flow.
    2. Encapsulate G-SRv6 Routing Header (Generalized SRH).
    3. Implement COC Flavor, and G-SRv6 Local SID Table.
    4. Implement End, End.X, End.DT6 as defined by SRv6 (G-SRv6 is compatible with SRv6).

    …



- Topology with three layers
  - Three TE paths with 10+ hops (10+ SIDs in the SID List), for Apps with different SLA requirements.
    - Large bandwidth
    - Low latency
    - Security checking by SFC

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Evaluation: Application-aware G-SRv6 network, enabling 5G services

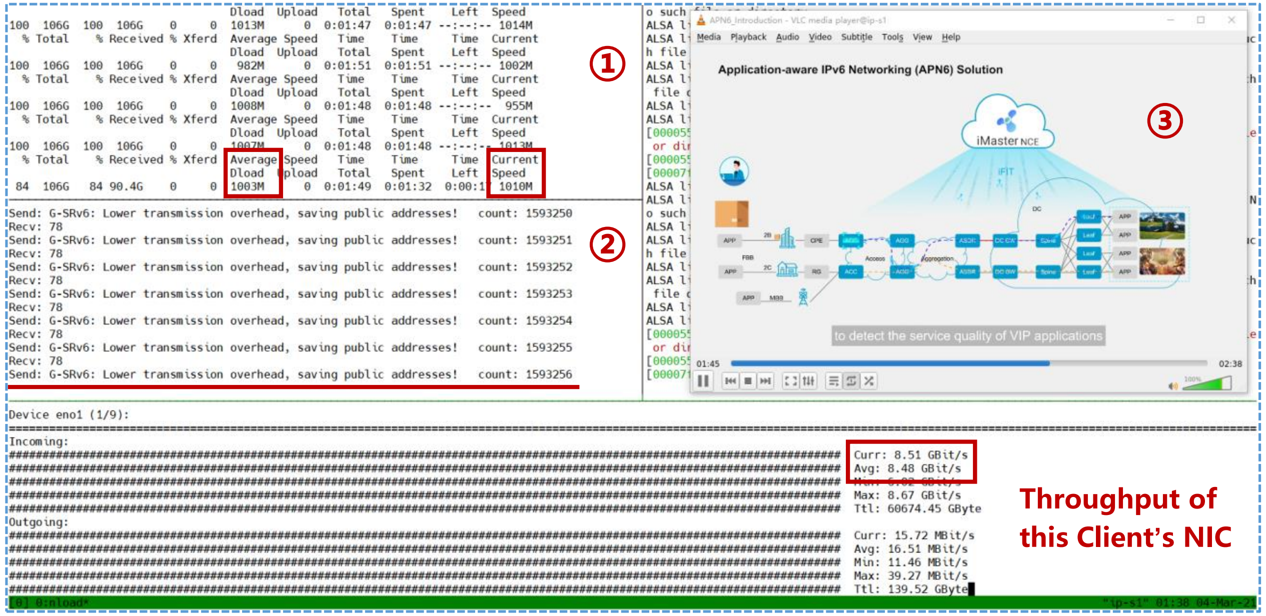
5G services & Applications:

- eMBB
  - ① Live video streaming (APN-ID 0xA)
  - ② File downloading (APN-ID 0xA)
- mMTC / uRLLC
  - ③ Interactive Control / Live & Short message (APN-ID 0xB / 0xC)

Performance:

- G-SRv6's Forwarding Rate is 55%+ higher than SRv6's
  - 620 Mpps vs 400 Mpps
- For 128 bytes payload, Overhead is reduced by 50%+
- Bandwidth Utilization is improved by ~10%
- Flow-Completion Time (FCT) is shortened by 10%+

Scheme	Application Throughput *	Network Throughput *	FCT *	RTT **	Forwarding Rate **	Bandwidth Utilization *
Best Effort (no APN)	0.94Gbps	0.94Gbps	923s	300.114 ms	/	10.28%
APN SRv6	7.48Gbps	9.01Gbps	114s	0.259 ms	400Mpps	83.07%
APN G-SRv6	**8.36Gbps**	**9.01Gbps**	**102s**	**0.259 ms**	**620Mpps**	**92.78%**



Reference

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- Lin He, Tsinghua, (he-l14@mails.tsinghua.edu.cn)

- Open Communities:
  - https://github.com/G-SRv6
  - https://github.com/APN-Community
  - https://www.ipv6plus.net
- G-SRv6 IETF Documents:
  - draft-lc-6man-generalized-srh
  - draft-cl-spring-generalized-srv6-np
  - draft-cl-spring-generalized-srv6-for-cmpr
- APN6 IETF Documents:
  - draft-li-6man-app-aware-ipv6-network
  - draft-li-apn-framework
  - draft-peng-apn-scope-gap-analysis
- Video materials:
  - https://www.bilibili.com/video/av672071616/
  - https://www.youtube.com/watch?v=qbryDg8fXRM
  - G-SRv6 @ IPv6+ Working Group

Thank you :)

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每个组织，构建万物互联的智能世界。

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