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M. Kohno
F. Clad
P. Camarillo
Z. Ali
Cisco Systems, Inc.
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Architecture Discussion on SRv6 Mobile User plane
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Abstract

Layer separation is a powerful concept in system architecture. In the area of mobility, by separating GTP-U that is the overlay tunnel, and the IP transport network that is the underlay, the operation of the mobile network and the transport network can be separated, allowing them to evolve independently.

However, evolving individually at each layer promotes local optimization and may result in non-optimal solutions overall in the long run.

When a drastic architectural transition is required, for example, in the 5G era where various SLAs and completely new data intensive services are assumed, it is necessary to reconsider the architecture holistically, not from the viewpoint of individual part.

One of important value propositions of SRv6 mobile user plane is to create overlay with underlay optimization.

This document discusses the architecture implication of applying SRv6 mobile user plane. Then it takes 5G use cases as an example, and describes how these use cases are simply and effectively realized. Thus it shows that SRv6 mobile use plane is a right architectural choice for 5G era.

Status of This Memo

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1. Introduction

Layer separation is a powerful concept in system architecture. In the area of mobility, by separating GTP-U that is the overlay tunnel, and the IP transport network that is the underlay, the operation of the mobile network and the transport network can be separated, allowing them to evolve independently.

However, evolving individually at each layer promotes local optimization and may result in non-optimal solutions overall in the long run.

The well-known aphorism of David J.Wheeler says:

"All problems in computer science can be solved by adding another level of indirection."

But, as a corollary, it also says: "...that usually will create another problem." In other words, excessive use of tunnels is not good for an overall architecture.

Existing practices have reasonable grounds, so it is usually recommended to follow them. But when a drastic architectural transition is required, for example, in the 5G era where various SLAs and completely new data intensive services are assumed, it is necessary to reconsider the architecture holistically, rather than from the viewpoint of individual part.

SRv6 mobile user plane has been proposed as an alternative way to complement or replace GTP-U both in IETF [I-D.ietf-dmm-srv6-mobile-uplane] and 3GPP [TR.29892]. In the 3GPP CT4, the scope of the study was narrow (N9 only) and it was concluded not to accept as a candidate protocol for the user plane in 5GC based on Rel-16 stage 2 requirements. However, the future is still open given the heterogeneous access evolution and stringent data intensiveness.

SRv6 has also an advantage if it is used as a mobile user plane, because of its flexibility through Service Programming functions and the use of metadata, in addition to the simple and stateless traffic steering capability.

The 3GPP data plane entities such as UPFs and service functions can be implemented either as virtual or physical appliances. The fact that SRv6 has been supported on various platforms including custom ASICs, commercially available NPUs, programmable switches, Smart NICs, Linux Kernel, virtual forwarders on server and container networking, will make the deployment flexible.

Also, the declarative programming nature of SRv6 will provide the necessary distinction to clarify basic reachability vs constraint path vs service path, whereas existing practices depended on the layer separation - service overlay and underlay. In other words, one of the most important value propositions of SRv6 mobile user plane is the possibility to perform cross-layer optimizations.

This document discusses the architecture implication of applying SRv6 mobile user plane. Then it takes 5G use cases as an example, and describes how these use cases are simply and effectively realized. Thus it shows that SRv6 mobile use plane is a right architectural choice for 5G era.

2. Architecture Consideration and Necessity of Inter-layer Optimization

Historically, Mobile and Transport Network have been designed, standardized and operated separately. GTP-U has been defined as the mobile user plane. This is an overlay tunnel that runs over the Transport Network. Therefore, the underlying network cannot be directly controlled.

5G requires variety of SLA characteristics and flexible traffic steering towards various service functions. How to map the transport slice to mobile end-to-end slice has been being discussed in multiple WGs in IETF [I-D.rokui-5g-transport-slice], [I-D.clt-dmm-tn-aware-mobility].

They are based on the current assumption that underlying network is separated and agnostic. But it could be effective if the underlying network can be more interactive.

The evolution of architecture requires a review of conventional domain boundaries and practices. This way, inefficiencies caused by traditional practices can be reduced. For example, now that "CUPS" separated the Control Plane and User Plane, UPF, which is dedicated to forwarding, can be considered as an entity on the IP Transport Network.

And, as a matter of fact, layer reduction for efficiency has been done in other domains. Some data centers adopted native IP CLOS, avoiding using VXLAN for simplicity. Also broadband subscriber managements were simplified by using IPoE instead of PPPoE / L2TP.

In the context of mobile operators, SRv6 provides end-to-end simpler network operations thus decreasing the OPEX. SRv6 can also be applied to the mobility overlay, in which case it also has benefits as the tunnels are removed.

3. Terminology

The terminology used in this document leverages and conforms to [I-D.ietf-dmm-srv6-mobile-uplane].

```
                                  +-----+
                                  | AMF |
                                  +-----+
                                 /    | [N11]
                          [N2]  /  +-----+
                        +------/   | SMF |
                       /           +-----+
                      /              / \
                     /              /   \  [N4]
                    /              /     \                    ________
                   /              /       \                  /        \
   +--+      +-----+ [N3] +------+  [N9]  +------+  [N6]    /          \
   |UE|------| gNB |------| UPF1 |--------| UPF2 |--------- \    DN    /
   +--+      +-----+  TN  +------+   TN   +------+           \________/
```

Figure 1: Reference Architecture

- UE : User Equipment
- gNB : gNodeB
- UPF : User Plane Function
- SMF : Session Management Function
- AMF : Access and Mobility Management Function
- 3GPP data plane entities : 3GPP entities responsible for data plane forwarding, i.e. gNB and UPF
- TN : Transport Network - IP network where 3GPP data plane entities connected
- DN : Data Network e.g. operator services, Internet access
- CUPS : Control Plane and User Plane Separation
- VNF : Virtual Network Function
- CNF : Cloud native Network Function

4. SRv6 mobile user plane and the 5G use cases

4.1. Network Slicing

SRv6 network programming realizes network slicing. How to build network slicing using the Segment Routing based technology is described in [I-D.ali-spring-network-slicing-building-blocks]

Also, the stateless slice identifier [I-D.filsfils-spring-srv6-stateless-slice-id] has been proposed to enable per-slice forwarding policy and bandwidth manipulation.

In the typical GTP-U over IP/MPLS/SR configuration, 3GPP data plane entity such as UPF is a CE to the transport networks PE. This results in the following facts:

- A certain Extra ID such as VLAN-ID is needed for segregating traffic and mapping it onto a designated slice.
- PE and the PE-CE connection is a single point of failure, so some form of PE redundancy (using routing protocols, MC-LAG, etc.) is required, which makes systems inefficient and complex.

Another possibility would be that 3GPP user plane entities are deployed as VNF/CNF in a DC. In this case, slice in the DC network and other networks are to be inter-connected via DCI.

In either case, it would improve the scalability, QoS and efficiency, if the user plane entities directly support SRv6.

4.2. Edge Computing

Edge computing, where the computing workload is placed closer to users, is recognized as one of the key pillars to meet 5G's demanding key performance indicators (KPIs), especially with regard to low latency and bandwidth efficiency. The computing workload includes network services, security, analytics, content cache and various applications. (UPF can also be viewed as a distributed network service function.)

Edge computing is more important than ever. This is because no matter how much 5G improves access speeds, it won't improve end-to-end throughput because it's largely bound to round trip delay.

However, the current MEC discussion [ETSI-MEC] focuses on how to properly select the UPF of adequate proximity, and not on how to interact with applications.

SRv6 has an advantage in enabling edge computing for the following reasons.

- Programmable and Flexible Traffic Steering : SRv6's flexible traffic steering capabilities and the network programming concept is suitable for flexible placement of computing workload.
- Common data plane across domain : SRv6/IPv6 can be a common data plane regardless of the domains such as access, WAN, mobile, cloud, distributed data center, and computing workload.
- Stateless Service Chaining : It does not require any per-flow state in network fabric.
- Interaction with Applications : SRv6 can carry meta data, which can be used for interacting with applications.
- Functionality without performance degradation : Various information can be exposed in IP header, but it does not degrade performance thanks to the longest match mechanism in the IP routing. Only who needs the information for granular processing are to lookup.

It is even more beneficial if service functions/applications directly support SRv6.

4.3. URLLC (Ultra-Reliable Low-Latency Communication) support

3GPP [TR.23725] investigates the key issues for meeting the URLLC requirements on latency, jitter and reliability in the 5G System. The solutions provided in the document are focused at improving the overlay protocol (GTP-U) and limits to provide a few hints into how to map such tight-SLA into the transport network. These hints are based on static configuration or static mapping for steering the overlay packet into the right transport SLA. Such solutions do not scale and hinder network economics.

Some of the issues can be solved more simply without GTP-U tunnel. SRv6 mobile user plane can exposes session and QoS flow information in IP header as discussed in the previous section. This would make routing and forwarding path optimized for URLLC, much simpler than the case with GTP-U tunnel.

Another issue that deserves special mention is the ultra-reliability issue. In 3GPP, in order to support ultra-reliability, redundant user planes paths based on dual connectivity has been proposed. The proposal has two main options.

- Dual Connectivity based end-to-end Redundant User Plane Paths
- Support of redundant transmission on N3/N9 interfaces

In the case of the former, UE and hosts have RHF(Redundancy Handling Function). In sending, RFH is to replicate the traffic onto two GTP-U tunnels, and in receiving, RHF is to merge the traffic.

In the case of the latter, the 3GPP data plane entities are to replicate and merge the packets with the same sequence for specific QoS flow, which requires further enhancements.

SRv6 mobile user plane has some advantages for URLLC traffic. First, it can be used to enforce a low-latency path in the network by means of scalable Traffic Engineering. Additionally, SRv6 provides an automated reliability protection mechanism known as TI-LFA, which is a sub-50ms FRR mechanism that provides protection regardless of the topology through the optimal backup path. It can be provisioned slice-aware.

With the case that dual live-live path is required, the problem is not only the complexity but that the replication point and the merging point would be the single point of failure. The SRv6 mobile user plane also has an advantage in this respect, because any

endpoints or 3GPP data plane nodes themselves can be the replication/ merging point when they are SRv6 aware.

5. Incremental Deployment

Incremental deployment should be considered. In the case of hcin mobility [I-D.auge-dmm-hicn-mobility-deployment-options], the insertion with no modification to the existing 3GPP architecture is considered first, and then the tighter integration of data plane is to be achieved. The same shall apply in the case of SRv6 mobile user plane.

6. Security Considerations

TBD

7. IANA Considerations

NA

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Authors' Addresses

Miya Kohno
Cisco Systems, Inc.
Japan

Email: mkohno@cisco.com

Francois Clad
Cisco Systems, Inc.
France

Email: fclad@cisco.com

Pablo Camarillo Garvia
Cisco Systems, Inc.
Spain

Email: pcamaril@cisco.com

Zafar Ali
Cisco Systems, Inc.
Canada

Email: zali@cisco.com