The Study on SRv6 for User Plane in 5G-Advanced and 6G Mobile Networks

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***Abstract*— SRv6 (Segment Routing over IPv6) is currently the ever-emerging new IP transport technology that pledges to remove a lot of complexity, while at the same time providing network programmability and integration with higher-layer application, which have been widely considered in the next generation of mobile core transport networks. With significant advantages of programmability, scalability, flexibility and simplification, SRv6 has been suggested to be adopted to 5G mobile core network for replacing a specific type of tunneling protocol (GTP-U: GPRS Tunneling Protocol User Plane) over which user-plane data traverses. We propose, after reviewing the SRv6 architecture and 5G mobile system (5GS), the signaling procedures related to session management under mobile core networks using SRv6 to make the 5G core network architecture more flexible.**

Keywords—5G-Advanced, 6G, Mobile Core, Programmability, SRv6, PDU Session

I. INTRODUCTION

Next-generation mobile communication systems(e.g., 6G) intend to accomplish high spectral and energy efficiency, ultra-low latency and massive connectivity because of large-scale development in the number of wired/wireless devices. These devices will meet rapidly growing application services such as smart home traffic, augmented reality(AR)/virtual reality (VR), ultra-high definition (UHD) live video streaming, which are expected to give people an amazing virtual world. These services require mobile network with low-latency path and high-bandwidth resources under strict requirements. Consequently, the data-path in the mobile network needs complex provisioning according to the characteristic of services in advance.

Moreover, mobile network's current architecture does not take the IP underlying transport network into account when determining the path for user data. A mobile network is partitioned into access networks, core networks and data networks, closely linked by tunnels. These trends have made it difficult for the mobile operators to manage and handle network paths efficiently [2]. Meanwhile, application services have shifted to use IPv6, and network operators have tended to select IPv6 as their underlying transport protocol. SRv6, the IPv6 with a new source routing extension header [3], unites both the higher application layer and the underlying transport layer into a single transport network (IPv6), allowing network operators to make use of network resources effectively in a concise way and eliminating the need to keep forwarding information from the network devices along a specified path [2]. In addition to the above description, SRv6 is best known for having native IPv6 attributes, simplifying the network protocol, unifying transport and mobile networks, and easy of use for end-to-end application functions [4]. Due largely to advanced features of SRv6, the members in 3GPP [6] or IETF [2] have studied the wide applicability of SRv6 architecture to mobile core networks.

The focus of this work is the procedures related to session management for user-plane using SRv6 instead of GTP in mobile networks. This paper organizes as follows: the next section briefly introduces the overview of SRv6. Section III describes the architecture design and signaling procedures for SRv6-based session management of 5G-Advanced and 6G mobile core networks. Section IV concludes this paper.

II. RELATED WORK

The following describes fundamental principles of SRv6 playing SRv6 node roles, segment routing header (SRH), the construction of SRv6 segment identifier (SID).

A. 3 roles of SRv6 nodes

- Source SRv6 Node: a node that encodes a SRH in an IPv6 packets.
- Transit SRv6 Node: any node on the path of the packet, but that is not the endpoint of a segment.
- Segment Endpoint Node: any node that receiving and processing an IPv6 packets in which the destination address field in IPv6 header has the node's local SID.

B. IPv6 along with Segment Routing Header

To implement Segment Routing over IPv6, SRH is introduced in RFC 8754 [5], shown in Figure 1. SRH consists of three parts: Header, Segment List, and Optional TLV field. The SRH expresses a SR-obvious-path, which is conveyed by segment list fields in an SRv6 SRH. The segment list information is made up of segments and placed in reverse order.

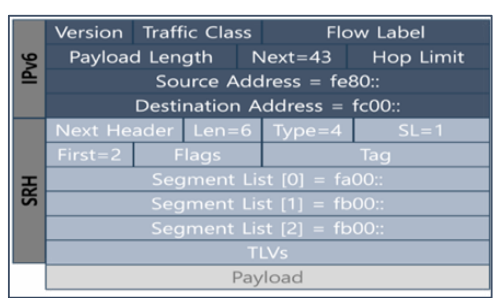

Figure 1. Segment Routing Header (SRH)

C. Construction of SRv6 SID

The segment in each SRv6 path is identified by a SID, which is formatted using by an IPv6 address being divided into three fields including Locator, Function, and Arguments [3]. In order to place SRv6 in the protocol of user plane, the prefix of SID must be followed by the Arguments part which is used to convey the tunnel identifiers. A possible encoding method is shown in the Figure 2.

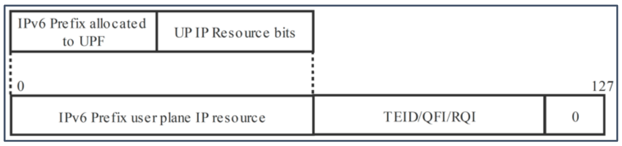

Figure 2. A SID encoding format for SRv6 tunnel

There are two user plane modes that vary with whether or not to use intermediate nodes: traditional mode and enhanced mode. These two different modes assume that the data plane's nodes are SRv6-aware. In the traditional mode, the 3GPP UPFs keep the current mobile mechanisms of the data plane with the only exception of the replacement of GTP-U with SRv6[2]. In enhanced mode, several nodes may be traversed between SRv6-aware UPFs.

Figure 3 shows that the UPF with unchanged (R)AN allows the (R)AN to use GTP-U/UDP over IPv4/IPv6 in the N3 interface.

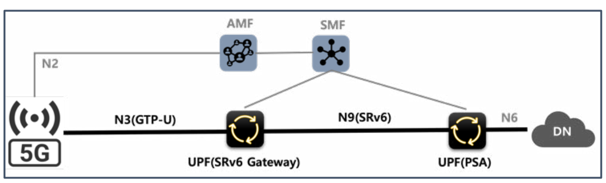

Figure 3. UFP enhanced mode with unchanged (R)AN

Figure 4 shows a mobile topology with enhanced mode. The figure indicates two service nodes, service function and traffic engineering. Note that neither service function nor traffic engineering are required to have an N4 interface.

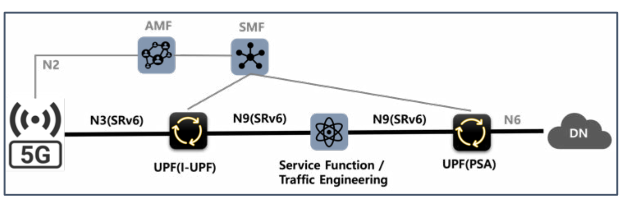

Figure 4. UPF enhanced with traffic engineering, and service programming

III. Architecture Design

Figure 5 shows the simplified network architecture of a 5G mobile system introduced in the 3GPP TS 23.501 5G System Architecture specification [1]. There are quite a lot of stimulating architectural construction and alterations in 5G core network when compared with previous generations such as the control and user plane separation to enable each plane to scale up and down independently; service-based architecture (SBA) to provide scalability and extensibility to the control plane of mobile core networks by revealing its functionality through service-based interfaces (SBIs) using HTTP/2 RESTful APIs; and the support of diverse access networks rather than only the 3GPP 5G NG-RAN network.

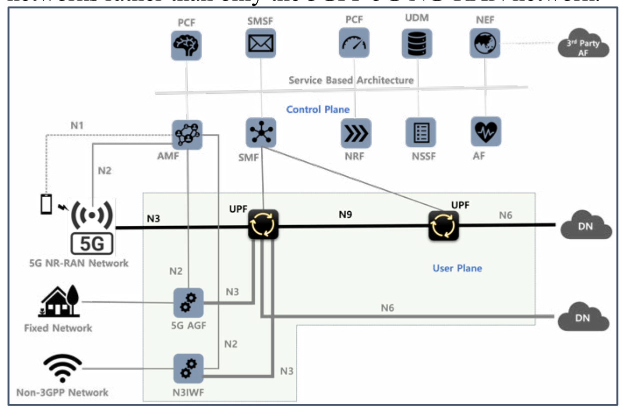

Figure 5. High−level architecture of a 5G system

The UE will carry out a series of steps to register with the 5GS in which AMF validates the UE with subscription information and authentication data from the UDM/AUSF in the SBA to make sure that the UE definitely has a proper subscription in the 5GS. When the UE's registration procedure is successfully finished, the UE will ask the control plane to establish a PDU session through the (R)AN via the N1 interface [1].

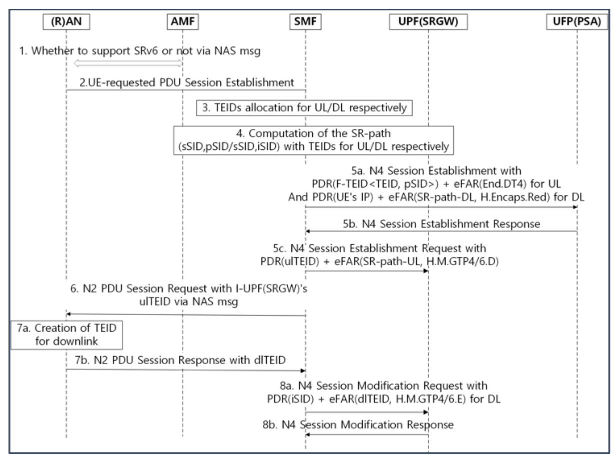

Figure 6. PDU session establishment in enhanced mode with unchanged (R)AN

Figure 6 shows the procedure for PDU session establishment using GTP-U with the (R)AN on the N3 interface. The procedure is described step-by-step as follows:

1. (R)AN and mobile core should confirm whether or not the SRv6-feature is supported.
2. The UE requests the AMF to establish a PDU Session through (R)AN via N1 interface.
3. The SMF allocates a pair of uplink and downlink TEIDs (Tunnel Endpoint Identifier) for a PDU session.
4. The SMF computes the SR-path with a pair of uplink/downlink TEIDs for uplink/downlink forwarding.

5. The SMF assigns intermediate/anchor UPFs and then begins N4 session establishment towards these UPFs respectively in order to configure the PDU Session.
6. When successfully assigned network resources for a PDU Session at each UPF, the SMF then posts an accept message of PDU Session establishment toward the UE as well as the QoS towards (R)AN via NAS N1 interface.
7. The (R)AN replies to the AMF with TEID about the its downlink forwarding.
8. The SMF informs the (R)AN TEID to the adjacent UPF (Segment Routing Gateway; SRGW) for DL forwarding.

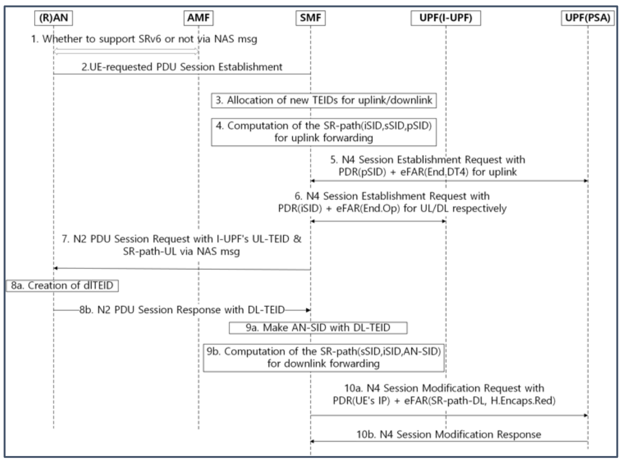

Figure 7. PDU session establishment in enhanced mode

Figure 7 shows the procedure for the PDU Session Establishment in which the (R)AN at the N3 interface uses SRv6. The procedure is described step-by-step as follows:

1 – 3. Same as in Figure 6.

4. The SMF computes the SR-path with a series of TEIDs for uplink (UL) forwarding.
5. The SMF assigns UPF(PSA) and then begins a procedure for N4 session establishment towards that PSA for uplink forwarding.
6. The SMF also selects an intermediate UPF and then takes action on the procedure for N4 session establishment towards that UPF for data forwarding.
7. The SMF then dispatchs an accept message for 5GS PDU Session Establishment towards the UE as well as the UFP TEID, QoS information and uplink SR-path towards (R)AN.
8. The (R)AN replies to the AMF with TEID about the its downlink forwarding.
9. The SMF computes the SR-path with a series of TEIDs for downlink forwarding.
10. The SMF also selects an anchor UPF and then modifies N4 session establishment towards that UPF for downlink forwarding.

IV. Conclusion

In this paper, we proposed a session management procedure for SRv6-aware user plane of 5G-Advanced and 6G mobile core networks. Mobile network operators can explicitly control user data paths across the mobile network since the SRv6 allows a source routing-based user data transport. When SRv6 is adopted in 5G-Advanced and 6G mobile networks, we expect that the mobile network can have more flexibility, efficiency, and simplicity in controlling user data traffic according to its requirements.

Acknowledgment

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