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AN ADOPTIVE AND RESILIENT SEGMENT ROUTING VERSION 6 POLICY TO ADDRESS TIGHT SERVICE LEVEL AGREEMENT REQUIREMENTS IN 5G NETWORKS

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ABSTRACT

There is ongoing work positioning Segment Routing version 6 (SRv6) as a replacement to General Packet Radio Service (GPRS) Tunneling Protocol User Plane (GTP-U). The main benefits of using SRv6 include coupling of the mobility overlay with the underlay (transport Traffic Engineering (TE)) and service chaining (GiLAN) and reusing high performance routers with SRv6 capabilities as User Plane Functions (UPFs). Techniques are described herein for enabling the creation of specific network slices where in the underlay a high resiliency is achieved with zero packet loss for tight Service Level Agreement (SLA) enterprise premium traffic. This same mechanism may be reused for path monitoring (e.g., latency, jitter, etc.) using in-band mechanisms for Ultra-Reliable Low Latency Communications (URLLC).

DETAILED DESCRIPTION

One of the most challenging but essential requirements for 5G networks is to support services with ultra-low latency, jitter, and loss with tight Service Level Agreement (SLA) requirements (e.g., Ultra-Reliable Low Latency Communications (URLLC)). Special consideration is needed to meet such tight SLAs bounds. These considerations include providing a policy which is resilient to jitter and packet loss. These considerations also include monitoring the latency and jitter using hardware-friendly in-band mechanisms and taking corrective actions if the SLA is violated.

There are multiple components to this solution. One is a new type of Segment Routing (SR) – Traffic Engineering (TE) policy with new SR version 6 (SRv6) endpoint functions.

At the head-end, the traffic associated with the ultra-low latency, jitter, and loss requirement is steered into the type of SR-TE policy called a Spray Policy. The Spray Policy replicates the packets over Segment Identifier (SID) lists that encode disjoint paths in the network. Replication uses the fabric multicast capability. Typically, the packets are replicated over two disjoint SR paths, but replication over more than two paths is also possible. Each packet is tagged with a flow ID and a sequence number in "Endpoint with Merge" (End.MRG) SID arguments. All the SID lists of the Spray SR policy will contain at one point the same segment. This segment is the End.MRG Segment and will contain as SID arguments the Flow ID and SeqNumber.

The endpoint of the Spray Policy is represented by the last SID. At the endpoint, End.MRG, which is a new SRv6 SID function, is usually introduced. End.MRG may be a variant of the End function that can also be combined with any function (e.g., End.DT4, End.DT6, End.DX4, End.DX6, the Penultimate Segment Popping (PSP) flavor defined in the SRv6 network programming document, etc.).

Alternatively, the FlowID and SeqNumber may be encoded as part of a Segment Routing Header (SRH) Type-Length-Value (TLV), rather than as part of the End.MRG SID arguments.

Upon reception of a packet with the active SID bounded to an End.MRG function, the node checks whether a packet with same (Source Address (SA), FlowID, SeqNumber) has been delivered. In case another replica of this packet has indeed been delivered, the current packet is dropped. Otherwise, the packet is delivered and the state is recorded.

Figure 1 below illustrates an example overview of the solution described herein.

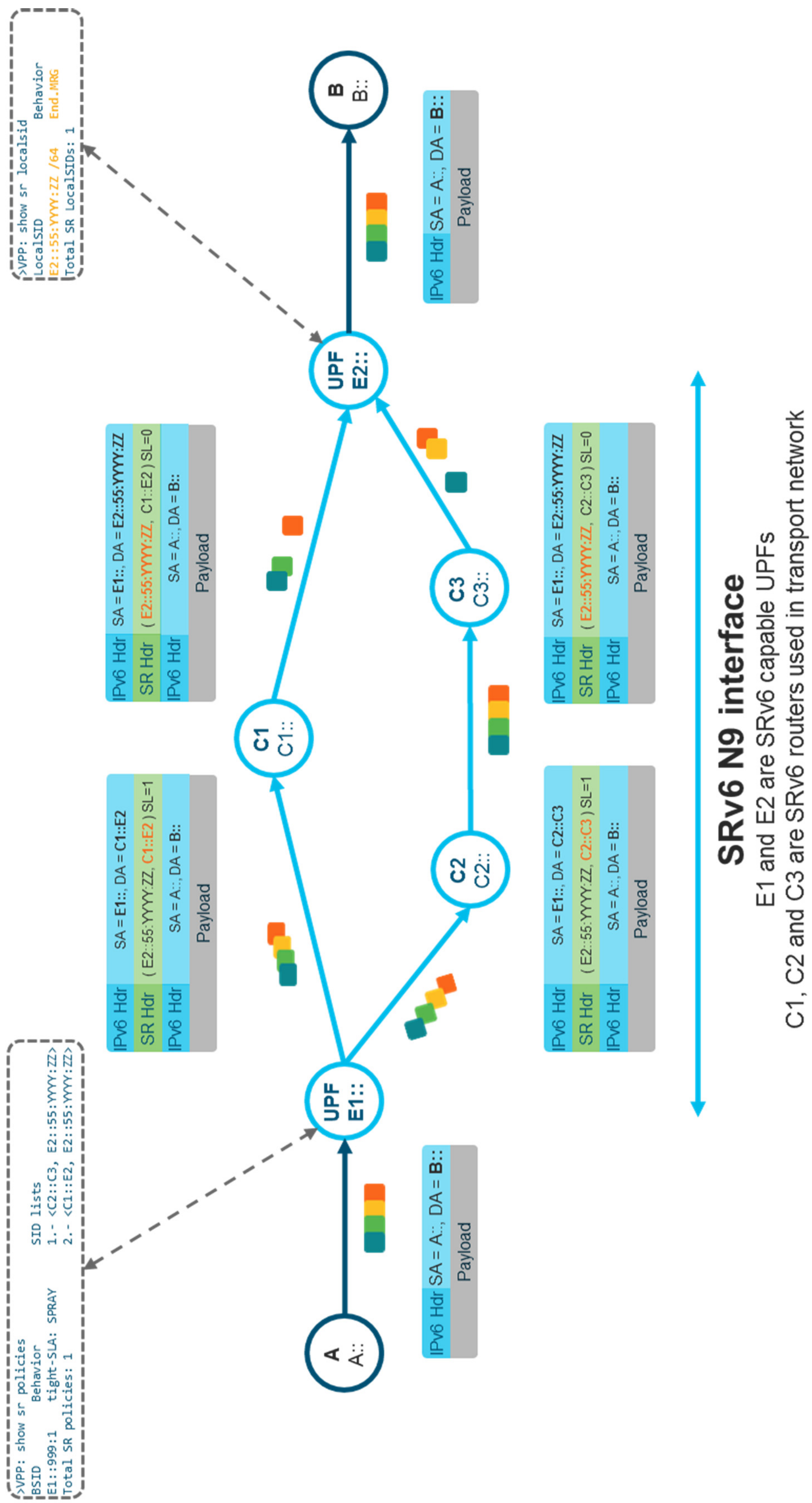
>VPP: show sr policies
BSID Behavior SID lists
E1::999:1 tight-SLA: SPRAY 1.- <C2::C3, E2::55:YYYY:ZZ>
2.- <C1::E2, E2::55:YYYY:ZZ>
Total SR policies: 1
>VPP: show sr localsid
LocalSID Behavior
E2::55:YYYY:ZZ /64 End.MRG
Total SR LocalSIDs: 1
A
A::
UPF
E1::
C1
C1::
C2
C2::
C3
C3::
UPF
E2::
B
B::
IPv6 Hdr SA = A::, DA = B::
Payload
IPv6 Hdr SA = E1::, DA = C1::E2
SR Hdr (E2::55:YYYY:ZZ, C1::E2) SL=1
IPv6 Hdr SA = A::, DA = B::
Payload
IPv6 Hdr SA = E1::, DA = E2::55:YYYY:ZZ
SR Hdr (E2::55:YYYY:ZZ, C1::E2) SL=0
IPv6 Hdr SA = A::, DA = B::
Payload
IPv6 Hdr SA = E1::, DA = C2::C3
SR Hdr (E2::55:YYYY:ZZ, C2::C3) SL=1
IPv6 Hdr SA = A::, DA = B::
Payload
IPv6 Hdr SA = E1::, DA = E2::55:YYYY:ZZ
SR Hdr (E2::55:YYYY:ZZ, C2::C3) SL=0
IPv6 Hdr SA = A::, DA = B::
Payload
IPv6 Hdr SA = A::, DA = B::
Payload
SRv6 N9 interface
E1 and E2 are SRv6 capable UPFs
C1, C2 and C3 are SRv6 routers used in transport network

Figure 1

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This solution applies to tight SLA enterprise premium traffic that is very sensitive to packet loss.

Additionally, this mechanism may be extended for in-band Operations, Administration, and Management (iOAM) purposes. In such case, a timestamp may be added in the SRH. This mechanism may be used in all the network slices where URLLC is needed as a way to monitor the underlying transport network (e.g., N3, N9 interfaces).

If the routing in the transport network is suboptimal, the network slice may be reconfigured to use the low-latency path. For this use case, the endpoint of the Spray Policy also records the received timestamp as early as possible at the ingress pipeline in hardware. As the packet is delivered after a very short time, it is sufficient to encode the current millisecond and microsecond values in the SRH tag as a compressed timestamp.

Delay encountered by each packet received on all SID lists is monitored. If a packet misses the delay bound, the (SA, FlowID, SeqNumber, measured delay) tuple is telemetered to a controller. If any SRv6 SID list is unable to meet the SLA requirements, the controller re-computes a better list that is disjoint from the other active segment list(s) and updates the SID list violating the SLA.

The techniques described herein meet the ultra-low latency, jitter, and loss requirements with tight SLA bounds, and utilize SRv6 programmability attributes with TE capability within a single layer. This solution is hardware friendly because the compressed timestamp is encoded in the SRv6 SRH tag, instead of a TLV. This solution is also hardware friendly because the Spray Policy uses a fabric multicast capability without state in the fabric. The SLAs are monitored using in-band mechanisms as opposed to synthetic probes. These techniques are proactive and adaptive, as a segment list that cannot make the tight SLA bounds is replaced with a better segment list without causing any traffic loss or SLA violations to the service.

In one variation of the SR TE Spray Policy, a flow ID and sequence number are included. A new SRv6 network programming End.MRG function is provided for packet de-duplication (duplicate removal). Traffic is time-stamped for URLLC network slice path monitoring. At the tail-end node, based on the delay encountered in received packets, packet information is telemetered to a controller, which re-computes a better disjoint path and updates the SID lists. These features offer a full solution to ongoing URLLC network slicing leveraging current user-plane protocol study for SRv6.

SR provides overlays (Virtual Private Networks (VPNs)), underlays (TE-Fast Reroute (TE-FRR)), and service chaining (Network Function Virtualization (NFV), GiLAN) all from a single unified protocol and without state in the fabric. This means that operators have full flexibility to route traffic throughout the network in any desired manner. This is a very powerful tool, but in order to take advantage of it the operator needs to have visibility of the network itself (e.g., real-time latency, link utilization, etc.).

SR also provides a solution for replicating traffic over several SR paths via Spray Policies, which are mainly used for content delivery purposes. As described herein, the Spray Policies are leveraged and a SID endpoint function is added to serve as a rendezvous point and for iOAM capabilities. This addresses the tight SLA requirements of next generation mobile networks.

It will be appreciated that although the procedures described herein are discussed with reference to the specific use case of 5G using SRv6, these techniques are applicable to other networking technologies and/or use cases.

In summary, techniques are described herein for enabling the creation of specific network slices where in the underlay a high resiliency is achieved with zero packet loss for tight SLA enterprise premium traffic. This same mechanism may be reused for path monitoring (e.g., latency, jitter, etc.) using in-band mechanisms for URLLC.