Segment routing in the 5G era

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Introduction

5G brings with it the promise of a range of new services from the faster speeds of enhanced mobile broadband to mass deployment of machine-type communications to ultra-reliable low-latency applications. With this range of services comes a pressing need to design network infrastructure that can easily and efficiently support a range of service types. In IP/MPLS networks, deterministic, SLA-based services were traditionally supported by implementing traffic engineering using protocols such as RSVP-TE. This approach, for some operators, was considered complex and difficult to scale. Segment Routing (SR) was introduced as an approach to reduce network complexity and provide a foundation for support of SLA services, reliability, and performance in core router networks. Its ability to run over any data plane and to leverage cloud-based path computation has made it a natural complement to the introduction of SDN.

This report explores the role of SR in IP network evolution, the key benefits for service providers, and where we are at with adoption within the industry. It also looks at the evolution of SR for addressing the requirements of new and emerging 5G services, including new implementation options for SR in IPv6 networks.

IP network evolution underway

Over the past decade, IP has become the dominant underlying technology for data transport. With no obvious technology successors, the need for IP routing will not go away anytime soon. However, the way routing is delivered into the network will evolve in order to address the ongoing quest to drive down network cost and increase agility to better address 5G and other cloud-driven consumer and enterprise services. SDN & NFV, disaggregation, and learnings from data center network architectures have all had some influence on how routing architectures may evolve over time. However, SR has already become widely accepted as an important tool in addressing some of the immediate evolution requirements in IP networks. Some of these include:

More scale

One thing has not changed: the demand for network capacity continues to grow, and there are no signs of demand abating. To meet bandwidth demand while reducing cost per bit transported, the industry continues to evolve router interface speeds. In the most recent cycle, 100GE upgrades pushed core router investment upward and, to a lesser degree, edge routers—a trend that we expect will continue as 100GE replaces 10GE over many years as the main interface speed. Now we are on the cusp of the next cycle with 400GE making its initial appearance in late 2019 for intra- and inter-data center applications. We expect more broad deployments to start in mid to late 2020 as new 400GE-capable router line cards and associated transceivers hit the market. We expect 400GE will become a table-stakes requirement for IP core routers and drive a new wave of core router refresh investment by 2021.

Control plane scale is also a concern – with broader adoption of 5G including Massive Machine-type communications (MTC) and other IoT applications, the number of IP devices connecting to the network will continue to grow, forcing the need for a mechanism to better handle both capacity and control scale as new applications and connected devices ramp-up.

More reliability

With the emergence of 5G ultra-low latency services, there is a need to deploy, manage and assure deterministic latency and/or guaranteed bandwidth in the IP network. A key capability for delivering network service SLAs is to be able to reserve a path through the network that meets the required service characteristics, and further, to be able to quickly re-route that path in the event of a network failure. Traffic engineering is the main mechanism in IP networks to support SLA-services, and the ability to execute the fast re-route of paths is key to providing resiliency.

More efficiency

Once constant in the telecommunications industry is the continuing quest to drive down the cost per bit transported. In IP networks this can be achieved through the introduction of new technology, for example, transitioning from 100GE to 400GE. The advent of SDN and centralized control provides new ways to optimize and drive higher network resource utilization which can lead to deferral of expenditures and/or lower cost per bit. Over the years as IP services and networks have become increasingly complex, network operators are also looking for opportunity to simplify network protocols, equipment, and architectures.

SR has a role to play in enabling these requirements to be met in the most efficient and cost-effective manner possible

What is segment routing and why is it important?

What is SR? SR brings the concept of source-based routing together with centralized path determination to enable simplified IP network architectures, scalable traffic engineering and more efficient network resiliency mechanisms. Each of these characteristics are critical to the realization and delivery of new and emerging 5G services.

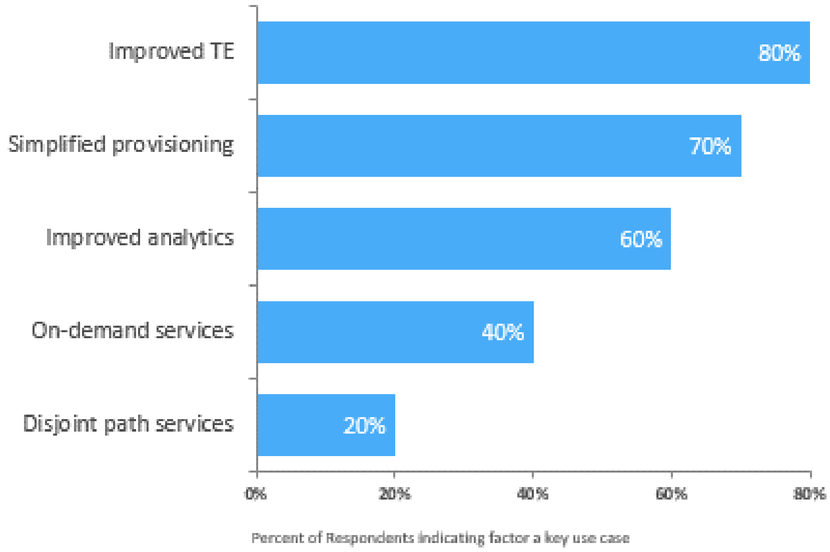
Traffic engineering provides the ability to determine the path service flows will take through a network and ensure the path is able to guarantee the bandwidth, latency and/or reliability required to ensure the any services running on top of that connection are able to function as designed. Segment routing brings a simplified approach to traffic engineering through removing the requirement for protocols such as RSVP-TE and LDP. It also has the ability to support ‘coarse grain’ traffic engineering or ‘fine grain’ traffic engineering depending on the requirements of the network operator. Centralized SDN control and path computation functions can also be leveraged to bring more visibility and better decision making to path selection to ensure optimal resource utilization.

Network resiliency is critical to being able to support high availability 5G services. IP/MPLS networks today support different protocols and mechanisms that can be designed to offer required resiliency. However, with segment routing and the support of a centralized path computation element, alternate paths through the network can be optimized and/or established in near real time to work around unforeseen outages and ensure traffic continues to flow and SLAs are met.

Service providers weigh in on the value of Segment Routing

As SR was just starting to take off, we conducted a custom service provider survey to better understand what network operators found attractive about SR, what they thought would be the key use cases and drivers for introduction into their networks. In this survey, improved traffic engineering came out as the top use case and was considered important or very important to 80% of our respondents. The ability to support simplified provisioning was also a key driver from this study.

Exhibit 1: Segment routing use cases



Source: IHS Markit custom survey on next-gen routing, 2018

Much has evolved in SR since the time of that study. SR is now an increasingly mature technology with established standards, a wide ecosystem of vendors that support it, and proven interoperability through extensive third-party testing from organizations such as EANTC. Most importantly, SR is now deployed in production networks around the world with service providers including Telefonica, Bell Canada, BT, Colt, SoftBank, China Unicom, VF Germany, and Comcast.

From the public announcements of these operators, segment routing was deployed in order to achieve the following objectives:

- Improve network scalability, reduce capex & opex
- Improve network availability
- Support per-service policy capability
- Support committed and/or deterministic SLAs
- Network slicing support
- Offer differentiated/value –add services
- Highly reliable mobile network that can handle 5G/IoT services

The majority of SR deployments today use MPLS as the forwarding plane. This is known in the industry as SR-MPLS, which runs seamlessly over IPv4 and IPv6 networks. With the maturity of SR-MPLS standards and solutions well in hand, router vendors are now developing and bringing to market other SR implementations that can be deployed on other forwarding planes including IPv6 without MPLS.

The move to segment routing for IPv6 networks

Interest is emerging in several countries to enable SR with IPv6 as the forwarding plane. This approach to SR over IPv6 comes in two variants SRm6 and SRv6 both of which share many of the same characteristics, benefits, and target applications of SR-MPLS. It also adds some new features with very interesting potential:

- **Increased reachability:** The 128-bit address space supported by IPv6 provides approximately 3.4x1038 addresses, more than enough to support the massive growth in network-attached devices expected with the growing adoption of IoT applications.

- **Simplified networking:** SRv6 and SRm6 use IPv6 extension headers to directly include IPv6- based segment IDs (SIDs) into the IPv6 packet. This implies that separate tunneling protocols such as L2TP, GRE, and even MPLS can be eliminated from the network, simplifying overall network operations and maintenance. The concept can also be extended to mobile networks where SRv6 or SRm6 could replace the GTP protocol, and even in the data center, eliminating the need for VXLAN. In effect, this approach can be used as a single unifying protocol from the device through to its destination, be it another device or application in the cloud with the appropriate capacity, latency, and reliability.

- **Network programmability:** One of the most interesting facets of leveraging IPv6 is the ability to enable a whole new range of network applications through a concept called “network programming” or “network engineering.” The way it works is very similar to how variables are passed to subroutines in computer programming. The network in effect becomes a computer in this paradigm. Network programming can provide an elegant solution to the challenge of providing connectivity to virtualized functions residing in data center locations in a simple, scalable, and secure manner. Other use cases for this approach include VPN services, service chaining, and traffic steering. The concept can also easily be expanded to add an unlimited range of new use cases in the future.

In comparing SR-MPLS with SRm6 and SRv6, there are differences in how traffic steering and network engineering functions are implemented. The following table highlights some of these differences with a focus on header mapping approaches.

Exhibit 2: Header mapping for Segment Routing forwarding planes

	Traffic Steering	Network Engineering
	SR-MPLS	
SR-MPLS	SR path is encoded in an MPLS label stack, each entry is encoded in an MPLS label stack entry (32-bits)	Instructions are encoded in MPLS labels
	SRm6 / SRv6	
Common Components	*Steer a packet from segment to segment along an SR path using an IPv6 Routing extension header*	*Execute an instruction at each segment endpoint*
SRm6	SR path encoded in Compressed Routing Header (CRH). CRH encodes each segment in 16 or 32 bits. Two lookups required	Instructions are encoded in IPv6 Destination Options
SRv6	SR path encoded in Segment Routing Header (SRH). SRH encodes each segment in 128 bits, one lookup required	Instructions are encoded in the low order bits of the IPv6 address

Source: Juniper

Opportunity ahead – adoption of IPv6 is key

According to a June 2018 report published by the Internet Society, 25% of the world's devices advertise IPv6 connectivity, and this is growing. We expect the initial deployments of SRv6 and SRm6 to align with the countries and/or network operators that have already implemented IPv6 networks, be it for lack of availability of IPv4 address space or because of national imperatives to deploy IPv6. China and Japan have broad availability of IPv6 because of national policy, and the deployments at China Unicom and SoftBank are well aligned with this. Although network operators in India support a mix of IPv4, IPv6, and dual-stack, Reliance/Jio as a large-scale new entrant implemented an all-IPv6 network. In the US, mobile network operators Verizon, Sprint, TMO, and AT&T all have high levels of IPv6 traffic and may also be candidates for SRv6/SRm6. However, there must be broader support for the technology in the incumbent router vendors in these accounts before we will see wider adoption in the US.

Bottom line

Segment Routing is now a well-accepted evolution path for simplifying IP/MPLS networks and for providing a solution to address the emerging requirements of 5G/IoT and service virtualization. As SR has gained acceptance and momentum in network deployments, the industry has continued to enhance and evolve the technology to better address different network environments and even more efficiently support new and emerging network services.

To learn more

Watch this free webinar

"Segment routing in the 5G era"

presented by Omdia and our partner

The webinar can be accessed at: https://bit.ly/2JhQy8a

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