How Segment Routing is Changing the Limitations in US Federal Network Architectures

A simpler approach for routing data that also works with legacy systems is poised to help agencies reboot their networks—and lower their costs.

By FedScoop Staff

Federal agency executives face a common conundrum: how to simplify their infrastructure to deliver services faster and more effectively in a technology age that seems to grow ever more complex.

That complexity looms even larger now as agencies grapple with the mechanics of migrating various applications and services to multicloud environments—while also trying to modernize their underlying networks.

Fortunately, the technology advances that led to software-defined networking have also bred a new generation of capabilities that can simplify the management of hyper-converged systems and multiple networks. The upshot for federal program teams: Even agencies burdened with legacy systems can achieve greater IT performance and versatility, lower their operating costs and enhance their security controls simply by taking advantage of these newer capabilities.

One networking capability that holds particular promise for budget-constrained agencies—and is gaining rapid adoption among large scale-network operators and architects—is a routing architecture called "segment routing."

The rise of segment routing

There's a good reason why organizations across the globe — from Walmart, to Google and Microsoft, to Bell Canada and Vodafone — are deploying segment routing.

Segment routing provides a more flexible and scalable approach for engineering how information travels to its intended destination. At its essence, segment routing gives network engineers a simpler way to encode and execute routing instructions for information packets. Moreover, it's ideally suited for the evolving nature of networks.

As importantly for agency leaders, segment routing:

- Allows agencies to reduce their IT footprint and operating costs.
- Provides greater interoperability and compatibility across new and existing networks.
- Offers more precise service levels for end-to-end access to applications.
- Provides for large-scale routing, high availability and 1-400Gb+ bandwidth.
- Reduces network congestion and increases overall network efficiency.
- Sidesteps the risks of vendor lock-in.
- Offers richer traffic-engineering capabilities that can improve mission services.

"Segment routing is a game changer," according to Craig Hill, distinguished systems engineer at the U.S. Public Sector division of Cisco Systems. "What segment routing has done is dramatically reduce the complexity in the network while adding key feature enhancements," he said. Organizations with large-scale networking demands are already putting segment routing to work.

"Segment routing has been growing like wildfire in the service provider market," said Joe Dorman, a solutions architect at Cisco. He pointed to Cisco customer data that shows a significant uptick in segment routing adoption over the past five years among cloud providers and large-scale enterprises. "Now we're starting to see it creep into our larger federal and other customers as they deal with the complexities of running wide area networks."

Inability to scale

The need for a simpler networking solution became evident to big IT services providers—and networking equipment makers like Cisco—several years ago as efforts to build out global networks were simply becoming "too costly and too difficult," said Dorman.

Prior to segment routing, multi-protocol label switching (MPLS) packets were forwarded using label switching instead of IP-based routing—which meant the routers forwarded traffic based on the label and not the destination address. This required only the "edge" routers to perform an IP lookup, while intermediate "core" routers performed only a label lookup.

This paradigm allowed an IP network to offer an entire set of transport services that has been in operation for the last 20 years for service providers.

Unfortunately, MPLS didn't remove any complexity from an existing network, and actually added it through additional protocols. Adding more complexity was that each MPLS node required the state to be synchronized across the entire network. As the size of networks grew, so did the state and complexity, making it more difficult to operate and manage.

A simpler solution

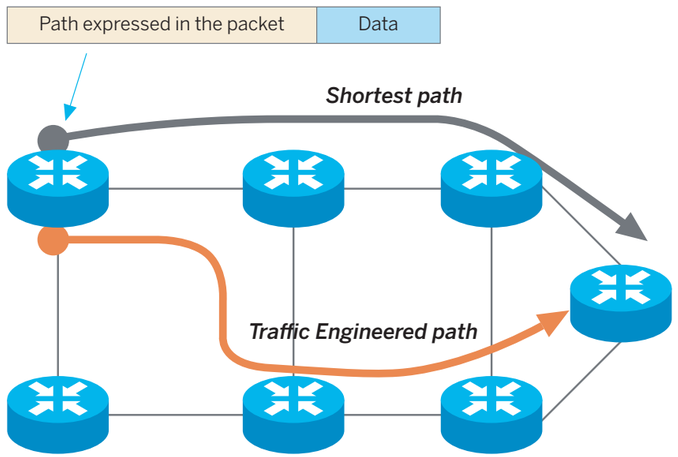
Segment routing removes the requirements for multiple protocols and network-wide synchronization, and their state, that traditional MPLS added, while still providing the same services and reducing the complexity of management and operations.

It utilizes a "source routing" technique in which the sending router specifies the route that the packet of information will take through the network—akin to a driver choosing a preferred route, depending on traffic conditions—rather than the path being chosen based on the packet's destination only. The result is greater control, which can be important when service level agreements (SLAs) need to be met.

More fundamentally, segment routing consolidates all the delivery protocols and encodes them into the packet header as an ordered list of instructions, or segments, that routers can read and redirect accordingly. Additionally, it natively supports fast rerouting around failures, without the need for complex backup traffic engineering tunnel provisioning.

Segment Routing

- **Segment routing architecture seeks the right balance between distributed intelligence and centralized optimization**
- **Segment routing delivers an unified, end-to-end policy aware network infrastructure while bringing unmatched simplicity and scalability**



Source: Cisco

Operational Advantages of Segment Routing

Segment routing can be deployed incrementally in production networks and seamlessly operate in brownfield environments while transitioning from legacy protocols. The technology also comes with a set of functionalities that can monitor and improve overall network and service resiliency.
Among other capabilities, segment routing delivers:

Stateless operation
Segment routing eliminates the need to create forwarding state instructions in the network, drastically reducing equipment and operational costs.

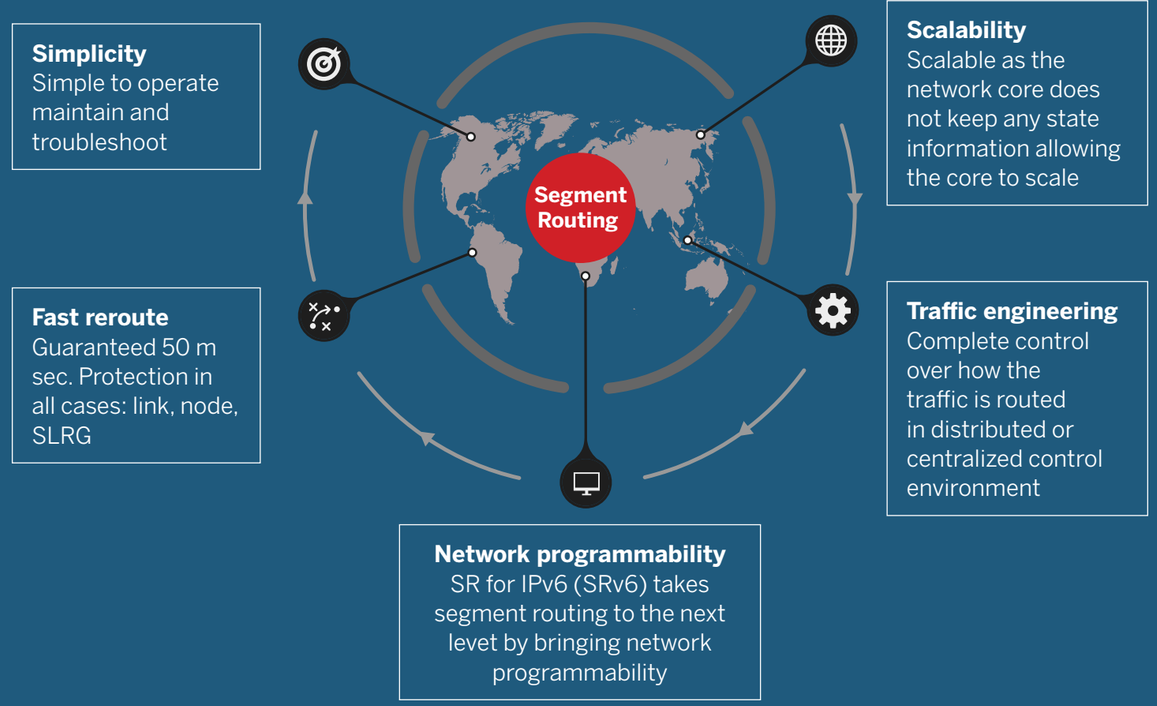
Robust scalability
SR eliminates path signaling, reducing network complexity and constraints.

Seamless deployment
SR runs natively on an MPLS or IPv6 data plane; but it can coexist with existing, legacy LDP networks, making migration painless.

Automated steering
SR can automatically steer traffic along arbitrary paths, based on SR policies, to meet low-latency and SLA requirements.

Unified forwarding plane
SR can create inter-domain transport policies while keeping local and wide area networks independent.

Rich functionality
SR facilitates a wide range of traffic engineering innovation, as well as native sub-50 millisecond convergence using Topology Independent Loop Free Alternative backup paths.



Source: Cisco, ASG Research

"From a product perspective, by pulling a ton of 'state' and simplifying the number of protocols in use, segment routing drastically reduces the size and cost of equipment agencies have to use to build large transport systems," said Dorman. "It also simplifies operations—agency networks can become simpler to use, and run on smaller, cheaper platforms."

Beyond SD-WAN

By optimizing the protocols, segment routing now makes it possible to deploy a variety of powerful network capabilities, that targets a different set of business and technology trends than those in SD-WAN.

"SD-WAN typically targets branch offices but doesn't give enterprises granular end-to-end control of their networks," explained Hill. "The ability to do line-rate encryption also does not exist when you start talking about high speed link security."

Segment routing, in contrast he said, is particularly well suited for agencies and organizations that want or need:

- Full control of their network—from end-to-end.
- Control over quality and service level agreements.
- High bandwidth backbone capabilities—from 10Gb to 400Gb speeds.
- Large-scale routing and high availability—"five nines" and beyond.
- Rich traffic-engineering capabilities—granular path control.

Creating a unified fabric

"What we're seeing now is that our enterprise customers want to build a single 'network fabric' that touches every network site they have across the globe and simplify their operations," said Dorman.

Segment routing can enable that by eliminating the need for running different transport protocols in different parts of the network, making it easier to transport information to any part of the network—across multiple domains—effectively creating a unified network fabric.

Microsoft's Senior Software Engineer Paul Mattes summed up the role segment routing plays in the context of SD-WAN architecture in a Cisco white paper saying: "We don't need to write our proprietary agent for every box we want to buy. Segment routing lets you program only the edge. We don't have the problem of tunnel setup synchronization; the network configures itself."

But segment routing has one other big advantage: It's designed to work with legacy systems, according to Hill.

"When segment routing was engineered, we recognized not every network is a green field; it has to integrate with brownfield environments, too—that is, the existing infrastructure," said Hill. "There are mechanisms native within segment routing, for example, that can map to a legacy MPLS label distribution protocol (LDP) backbone, allowing newer segment routing backbones to coexist with existing MPLS networks."

"People usually modernize a single component," observed Dorman. "We're trying to get them to modernize the whole system, having everything operate from a single control point."

See how Cisco can help simplify and transform your network capabilities with segment routing.

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Segment Routing: Where to Start

Here are eight considerations for agency decision makers and network designers in getting started with segment routing (SR):

1. Engage operation teams in assessing the technological and operational pain points of current IP/MPLS and IPV6 networks
2. Understand the different use cases SR targets and address those challenges first.
3. For brownfield environments, take advantage of SR's ability to co-exist with IP/MPLS networks without having to rip-and-replace existing networks.
4. Consider enabling SR in a smaller controlled domain in the network before scaling it globally, allowing experience in the technology and operations teams.
5. Assess the risks, but know SR is a low-risk initiative because the primary protocols are standards-based and can coexist with existing networks.
6. Take advantage of SR's ability to control traffic forwarding end-to-end, either locally or through an external controller (SR Path Computational Element).
7. Take further advantage of SR for IPV6 (SRv6) to collapse network layers, eliminate overlays, making networks more consolidated and simpler to operate.
8. Take additional advantage of SR unified fabric capabilities, with a single control plane such as E-VPN, to simplify end-to-end transport across multiple networks.