Application Engineered Routing: Segment Routing and the Cisco WAN Automation Engine

What You Will Learn

The Cisco® Application Engineered Routing solution provides end-to-end control over how the network infrastructure transports applications. In the past, dedicated clusters of servers would deliver specific applications, but the number and diversity of applications continue to increase as the infrastructure becomes more converged.

Traffic patterns are dynamically changing and new applications come with specific transport requirements. Combining Segment Routing (SR) with the Cisco WAN Automation Engine (WAE) provides the necessary intelligence to optimize network resources and make informed decisions dynamically, helping to ensure a consistent, high-quality customer experience.

This white paper describes SR and the Cisco WAE and highlights how they work together to deliver an intelligent, dynamic, highly optimized network.

Segment Routing Overview

SR allows for a unified, end-to-end, policy-aware network architecture from servers in the data center, through the WAN, and out to the aggregation and access areas of service provider and enterprise networks. Designed for software-defined networking (SDN), the SR approach provides the right balance between distributed intelligence, centralized optimization, and application-based policy expression. Other benefits include operational simplicity, better scale, and better utilization of the installed infrastructure.

SR is based on the principles of source routing, where a node (router, switch, or virtual forwarder) chooses and encodes the desired network path directly into the packet header as an ordered list of segments. A segment list provides the handling instructions to forward a packet throughout the network. For example, the instructions may say: “Go to node N using the shortest path” or “Go to node N over the shortest path to node M and then follow links X and Y to reach N.” With this approach, the network no longer needs to maintain the state per application or flow. Instead, it simply obeys the forwarding instructions provided in the packet.

In addition, SR satisfies essential requirements such as:

- The ability to provide strict network performance guarantees
- Efficient use of network resources (it is Equal Cost Multipath [ECMP] friendly, for example)
- Assurance of very high scalability for application-based transactions
- Increased scale and simplicity in the era of SDN where applications dictate required network behavior and where traffic differentiation and engineering are done at a finer granularity (i.e., it’s application-specific)
SR relies on a small number of extensions to the Intermediate System-to-Intermediate System (IS-IS), Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP) protocols. It can operate with a Multiprotocol Label Switching (MPLS) or an IPv6 data plane and integrates with the rich multiservice capabilities of MPLS, including Layer 3 VPN (L3VPN), Virtual Private Wire Service (VPWS), Virtual Private LAN Service (VPLS), and Ethernet VPN (EVPN).

Cisco WAN Automation Engine Overview

The Cisco WAE is a powerful and flexible SDN platform that automates the engineering and operations of multivendor physical and virtual infrastructure. It abstracts and simplifies the WAN environment while making it fully open and programmable, providing a consistent operational experience for optimizing and deploying innovative new services such as global load balancing, bandwidth calendaring, bandwidth on demand, and premium network routing.

Cisco WAE allows network operators to optimize their network infrastructure through the continual monitoring and analysis of the equipment itself and the demands being placed upon it. The WAE workflows consist of ongoing collection, predictive analytics, and deployment of the application and service requirements directly onto the infrastructure. This automated feedback loop from infrastructure to application takes full global visibility into account, helping to ensure that the rollout of any new optimization or monetization service does not affect existing network operations.

Figure 1 depicts a simple block diagram of the WAE platform and software modules.

Figure 1. Block Diagram of the Cisco WAE Platform

Cisco WAE provides a cross-sectional view of traffic, topology, and equipment state and takes advantage of a predictive analytical model that performs “what-if” analyses based on the effects of failure. These simulations can be performed at the rate of hundreds of thousands per second, and they provide a centralized, high-fidelity view of the network. This allows operators to predict the behavior of the network across planned and unplanned changes.

The explicit handling of new traffic demands based on how they affect the current network state helps ensure that networks can run at their optimal utilization with predictable performance and around link congestion or failures. As new SR traffic-engineered tunnels are added to the network, Cisco WAE promotes end-to-end optimization and load balancing within specified constraints in conformance with policies to help ensure compliance with service level agreements (SLAs).
Centralized Controllers and Segment Routing

SR is a compelling architecture conceived to embrace SDN. It strikes a balance between network-based distributed intelligence, such as automatic link and node protection, and controller-based centralized intelligence such as traffic optimization. It provides efficient use of network resources, and very high scalability for application-based traffic engineering.

When using centralized computation, WAE acts as a multivendor SR controller to provide fault-tolerant, centralized calculations of optimal SR paths meeting the specific application or use case requirements. For example, applications may specify minimum bandwidth or latency requirements or request a path that does not traverse certain parts of the global network, perhaps for security or other concerns. All policy requirements will be matched before WAE calculates the path. SR adds another benefit with automated and native Fast Reroute (FRR) capability, with sub-50-millisecond convergence time. SR supports FRR on any topology, without any additional signaling protocol, and it supports node and link protection.

Using Cisco WAE to provide centralized SR path computation provides multiple advantages, including:

- Networkwide view of topology and traffic information
- Multilayer (optical and IP/MPLS) topology views
- Steering some demands away from their best BGP path based on technical and business policies
- Historical traffic trends
- Calendaring capabilities over time, supporting future bandwidth requests
- Northbound APIs, which allow external applications and traffic sources to request specific network requirements

Path computation in large, multidomain networks is complex and requires special computational components and cooperation between the elements in different domains. In IP/MPLS networks, this functionality is referred to as a Path Computation Element (PCE), as defined by RFC 4655. Cisco WAE acts as an external PCE Server, providing a centralized traffic-engineering database (TED). Nodes, endpoints, and applications that wish to request network paths that differ from the standard Interior Gateway Protocol (IGP) shortest path can make Representational State Protocol (REST) API queries to WAE, which in turn calculates a network path matching the specific requirement. WAE then programs the network path to the network. In networks utilizing SR, Path Computation Element Protocol (PCEP) is the protocol commonly used between WAE and the multivendor nodes.

Figure 2 illustrates a scenario where WAE is acting as an external PCE Server for centralized SR path calculations. An application requests 2 Gbps of end-to-end bandwidth, however the IGP shortest path isn’t capable of providing it. WAE calculates the next-shortest path that fulfills the requirements and then uses PCEP to signal a list of segments to the head-end router (router A in the example). Note that with SR, the head-end router is the only router in the network that needs to be programmed by WAE, and it is the only place where this network state is maintained.
Figure 2. Step by Step Depiction of PCEP Tunnel Creation

Cisco WAE and SR Use Cases

SR Traffic Engineering use cases will vary based on the customer’s technical and business needs. For example, some customers have regulatory or business requirements to provide disjointed paths within their network, whereas others need to steer traffic with heavy loads away from the shortest path toward a sub-optimal routing path in order to optimize resource usage. With WAE acting as a central source of multilayer network information, these use cases can be fulfilled with more complete network knowledge. Optical paths can be considered for disjointness. Failure analysis calculations can help deliver optimal SR paths for both steady-state and worst-case failure scenarios. Path computation can be offloaded from the network nodes, scaled using clustered servers, allowing external applications to query a REST API for all network admission requests.

WAE can dynamically compute two disjointed paths to steer the traffic through them, optimizing to find the lowest-cost path and to avoid optical shared-fate scenarios that could lead to congestion problems. WAE programs router A with the associated segment list (Figure 3). Again, the head end router (router A) is the only node in the network that maintains the tunnel state.
Summary

Applications can program a segment routing-enabled network to perform end-to-end, application-based based routing from the data center through the WAN to the end user. SR and the Cisco WAE provide the essential capabilities that service providers and large enterprises need to deliver the end-to-end Application Engineered Routing solution.

These Cisco solutions are easy to deploy with a software upgrade on Cisco Evolved Programmable Networking (EPN) platforms. Cisco Application Engineered Routing automation and orchestration capabilities help simplify the creation of new services, improve time to market, and deliver a superior end-user experience. The solution is open, based entirely on open interfaces to allow multivendor deployment.

More Information

Anyone with a Cisco.com ID can test and demonstrate SR and Cisco WAE by accessing the Cisco dCloud and searching for SR and WAE in the demo catalog.


For more information related to SR, please visit: http://www.segment-routing.net/