White Paper

Application Engineered Routing: Let the Applications Program the Network

What You Will Learn

Interaction between applications and network infrastructure is increasingly important to service providers and enterprises. Greater interaction will help service providers optimize their network infrastructure and, more importantly, offer new services that can generate incremental revenues.

The Cisco® Application Engineered Routing solution can raise this interaction to a previously unachievable level. This simple and scalable architecture uses customer network assets and augments them with network programmability capabilities that allow applications to program the network, delivering end-to-end, per-flow policy from the data center through the WAN to end users.

The Problem

In the past ten years, service providers have invested heavily in network infrastructure because of exploding growth in IP traffic. During the same period, their legacy revenues either stalled or declined, while new revenue streams did not make up for the loss.

The lack of advanced interaction between applications and network infrastructure has contributed to this challenging situation in the following ways:

- Applications and network infrastructure have been running in isolation. Applications have limited or no visibility into network infrastructure state, and network infrastructure has no insight into which types of applications are being transported. These limitations have stifled service innovation and affected the service-level agreements (SLAs) delivered to end users.
- Traffic engineering solutions fell short of expectations, and as a result, service providers have invested in network infrastructures that are largely underutilized. Average link utilization, for example, is 40 percent - an inefficient use of capital resources.
- Implementation and operational complexity have led to a surge in operating expenditures, along with greater network instability.

Traffic engineering techniques, such as Multiprotocol Label Switching (MPLS) traffic engineering, were implemented in some service provider networks. However, they came with caveats concerning scalability issues, configuration and troubleshooting complexity, and more. Interaction between applications and network infrastructure was obviously enhanced, but not to the level required to meet the latest service provider challenges. For example:

- The sheer number of application flows is increasing, as a result of 4K video, mobility, cloud services, and the Internet of Everything.
- Application flows have increasingly dynamic and changing traffic patterns.
- Applications flow control in the WAN is no longer sufficient to deliver a best-in-class customer experience; end-to-end control is now required.

Legacy traffic engineering techniques are struggling to deliver the expected outcomes. So service providers need new tools to bring applications and network interaction to the next level, particularly in the software-defined network (SDN) era.

The Solution

The Cisco Application Engineered Routing solution is a breakthrough innovation specifically aimed at solving the issues just described. The solution has three main components: applications, an SDN controller, and a network infrastructure that allows Segment Routing. These components work together in the following ways (Figure 1):

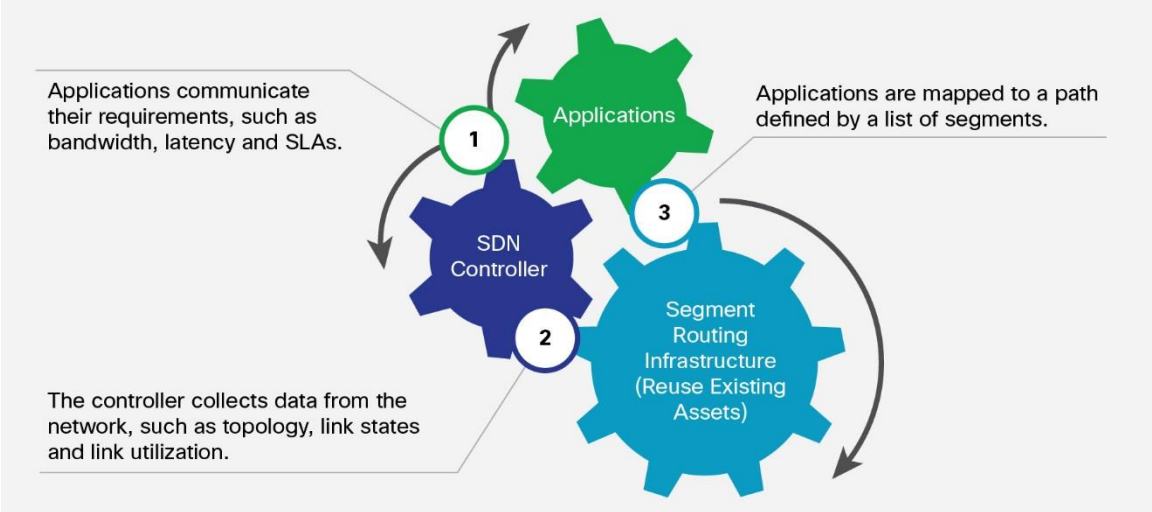
Step 1. The applications communicate their requirements, such as bandwidth, latency, SLAs, and preferred path to the SDN controller.

Step 2. The SDN controller collects essential data from the network, such as the topology, link states, and traffic matrix - including link utilization and latency. The SDN controller takes into account the application requirements and the overall state of the network, then computes a specific network path and encodes it as a list of segments.

Step 3. The SDN controller programs a single per-flow state at the first-hop router in front of the application. The specified flow is classified, and the list of segments is inserted in the packet header. From then on, the requirements of the application flow are delivered end to end by the multidomain network, from the data center through the WAN, and from Metro network on to the end users, without any further per-flow state programming, neither for forwarding nor for reclassification.

However, if the state of the network changes or the application communicates new requirements, the SDN controller computes a new network path, encodes it as an updated list of segments, and reprograms a single per-flow state at the first-hop router in front of the application. Other parts of network do not need to be changed.

Figure 1. Application Engineered Routing Components and Their Interaction



Segment Routing: The Power behind a New Solution

Cisco has been at the forefront of this routing innovation for two years, through thought leadership, standardization, product creation, and deployment. Customers across all segments, including Web providers, telecom service providers, and large enterprises, will start rolling out the technology in 2015.

Segment Routing has been designed for SDN and seeks the right balance between distributed intelligence, centralized optimization, and application-based policy creation. Other benefits of Segment Routing include operational simplicity, better scale, and better utilization of the installed infrastructure.

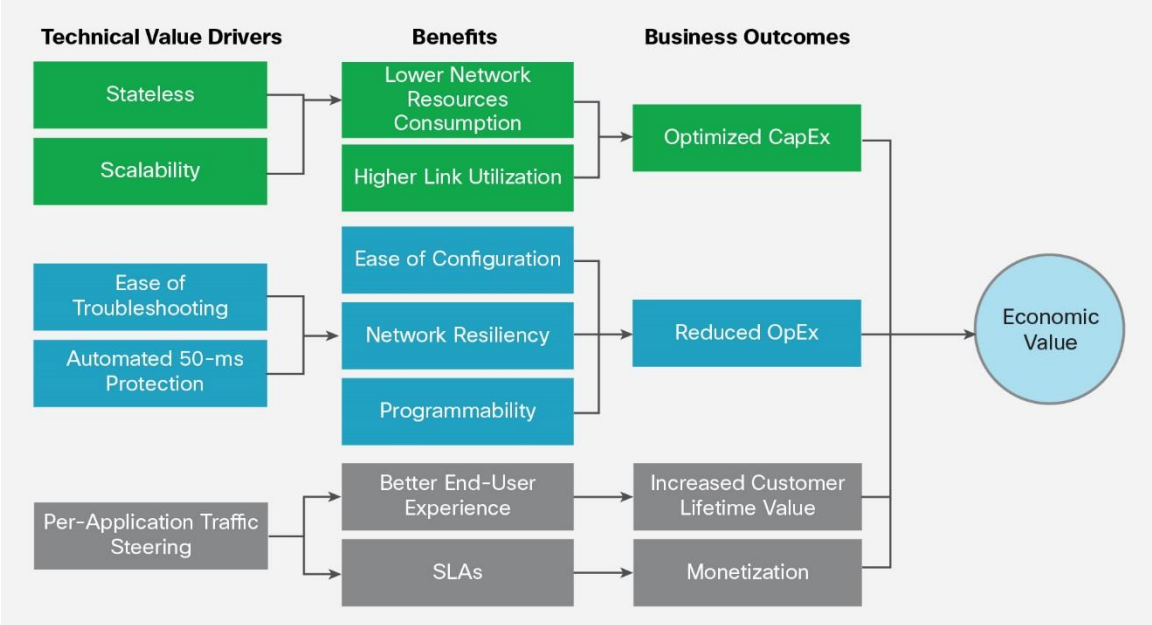
Segment Routing supports both MPLS and IPv6 data planes. And because it is fully interoperable with the existing MPLS control plane, as well as IPv6 data plane, it provides investment protection and allows incremental adoption.

Business Outcomes

Deeper interaction between applications and network infrastructure can bring a variety of positive business outcomes for service providers. For example, it can:

- Unleash service innovation that promotes incremental revenues. (By removing scalability barriers and augmenting the scope of the end-to-end, application-aware infrastructure, service providers can deliver new services that were simply not possible before.)
- Reduce capital expenditures, as dynamic rerouting of traffic allows higher asset utilization.
- Decrease operating expenses, as a result of simplified configuration and troubleshooting, along with greater network resiliency.

Figure 2. Business Outcomes of Cisco Application Engineered Routing



Use Cases

The Cisco Application Engineered Routing solution allows service providers to take full advantage of their network infrastructure, so they can offer new differentiated service offerings, as described in the sample use cases in Table 1.

Table 1. Cisco Application Engineered Routing Solution Use Cases

Use Case	Example
End-to-end policy with automated Fast Reroute	Market segment - Enterprises Increasingly, enterprises would like to have differentiated traffic policy for their applications. For example, some enterprise applications would benefit from being routed over a path with lower latency, while others would benefit from being routed over a path with higher bandwidth In fact, applications should be able to program the network on a per-flow basis by communicating their requirements. The application requirements are then programmed into the network end to end. To support stricter SLAs, network resiliency must be improved, so Cisco Application Engineered Routing offers automated 50-msec Fast Reroute capability
Avoidance	Market segment - Governments, security agencies Customers that deal with confidential and sensitive information are increasingly paying attention to which countries their data traffic might be routed through. Privacy and security are crucial concerns. As a result, they want their service providers to have control over the routes their traffic takes. Customers select a list of “authorized” countries, and the network determines possible routes
Egress peering	Market segment - WEB and content producers These customers rely on service providers to deliver their content to end users, and content is handed over at peering points. Having control over how the content is delivered at the peering links is of utmost importance, in order to: • Deliver a superior end-user experience (avoid congested links that could cause delays or even traffic loss) • Promote the best utilization of peering links (improve peering link cost management) Applications are routed over peering links by taking into account multiple factors, such as peering link utilization, costs, and state (up or down); commercial agreements between content producers and service providers; and so forth

Implementation

The Cisco Application Engineered Routing solution has been devised with the following objectives:

- Leverage customer’s past investments into network infrastructure
- Make network infrastructure more agile and simpler to operate

Three implementation phases have been identified, with each phase adding incremental value. Customers do not have to complete the implementation of all three phases to reap the benefits of their investment. At each phase, they are getting new benefits.

Phase 1

Segment Routing is enabled on the MPLS network infrastructure. This can be done with a simple software upgrade. Expected benefits include network simplification and improved network resiliency. Segment Routing delivers automated Fast Reroute (FRR) capability, with sub-50 millisecond convergence time. Segment Routing supports FRR on any topology, without any additional signaling protocol, and it supports node and link protection. In a network with Segment Routing, the FRR backup path is optimal, because it is provided over the post-convergence path, simplifying the operation and deployment.

Phase 2

An SDN controller is inserted, which can simultaneously collect data from the network and program the network infrastructure. It allows customers to:

- Optimize use of their network infrastructure
- Offer new differentiated service offerings, such as those described in Table 1

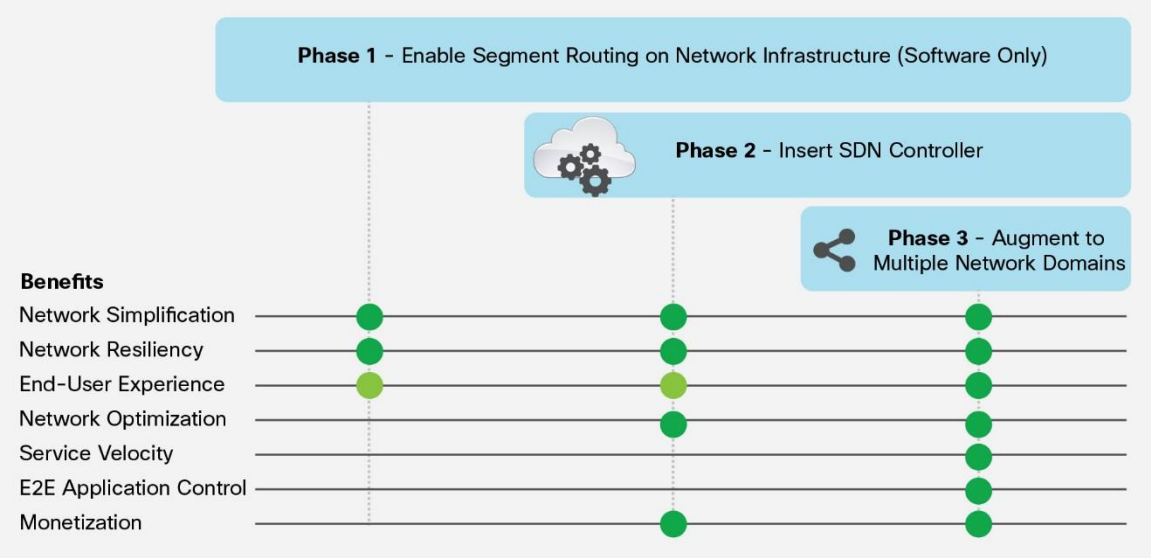
SDN controllers and the MPLS network infrastructure interact through standardized protocols, including Link State (BGP LS), Netconf/Yang, and Path Computation Element Communication Protocol (PCEP).

Because the solution is open, customers can choose to insert their own SDN controller.

Phase 3

The solution is augmented to multiple network domains. Interactions between the applications and the network infrastructure can be controlled end to end. Expected benefits include faster service velocity and expanded monetization opportunities.

Figure 3. Application Engineered Routing Journey



Conclusion

Given continuous growth in IP traffic and network devices - and the need to offer new targeted service offerings - service providers need to transform their network infrastructure as soon as possible. The objectives include making it simple, agile, scalable, and programmable.

The Cisco Application Engineered Routing solution addresses these four architectural goals:

- Simple: Fewer network protocols are required with automated sub-50-msec FRR protection.
- Agile: The solution works across multiple network domains (from the data center through the WAN, up to the end user), and it can be implemented on both physical and virtual network elements.
- Scalable: It provides single per-flow state in the network, increasing network scalability, and the ability to provide granular, per-application service.
- Programmable: Application requirements program the network using an SDN controller, so that end-to-end, per-flow policy can be delivered.

For More Information

Please visit http://www.cisco.com/go/epn for more information on Cisco Application Engineered Routing.

Americas Headquarters
Cisco Systems, Inc.
San Jose, CA

Asia Pacific Headquarters
Cisco Systems (USA) Pte. Ltd.
Singapore

Europe Headquarters
Cisco Systems International BV Amsterdam,
The Netherlands

Cisco has more than 200 offices worldwide. Addresses, phone numbers, and fax numbers are listed on the Cisco Website at www.cisco.com/go/offices.

Printed in USA C11-734244-00 07/15