Silver Peak Unity EdgeConnect SD-WAN Solution

MOS Test Results

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Contents

Executive Summary

The job of an enterprise Wide Area Network (WAN) simply put is to connect users to applications, balancing the requirement to support high quality connections while remaining cost-effective in delivering applications to its branch and remote office users. As WAN technologies advance, voice traffic is routed over the network which uses combinations of MPLS and broadband links. MPLS typically provides higher quality service at a higher cost, whereas broadband links offer larger bandwidth at a lower cost. To accommodate this hybrid of MPLS and Internet links, a software-defined WAN (SD-WAN) provides a scalable, secure solution for high efficiency, availability and performance to provide the highest quality voice and video user experience between branch and headquarters networks.

As SD-WAN deployments accelerate, some enterprises have begun adopting dual broadband strategies, forgoing MPLS altogether. This presents additional challenges on the SD-WAN solution to deliver business-grade voice quality even when internet services experience packet loss.

Silver Peak® engaged Miercom to independently quantify its Unity EdgeConnect™ SD-WAN solution for high quality voice communication over single and dual underlay links. The test bed included a pair of EdgeConnect XS appliances managed by Unity Orchestrator™. A series of tests were designed to demonstrate how Silver Peak addresses the various conditions an Internet link will exhibit. Tests were run with single and dual broadband links. To demonstrate a Voice over IP application, Miercom used a third-party tool to generate Voice over Internet Protocol (VoIP) traffic, as well as a background traffic load of 85 Mbps, in both directions on all links. The Silver Peak High Availability Link Bonding Policy was configured to demonstrate how EdgeConnect mitigates the effects of latency and corrects for packet loss that may occur on the WAN transport links.

Voice quality was measured over these links using the MOS (Mean Opinion Score) industry standard for the tests to determine if the EdgeConnect SD-WAN solution could sustain business-acceptable MOS performance greater than 3.0 using consumer grade broadband links.

- The first test was set up with a single underlying link with no path conditioning, 100 Mbps of background and VoIP traffic. Packet loss was increased until a MOS < 3.0 was reached
- A second variation of the first test was set up with a single underlying link with path conditioning enabled, 100Mbps of background and VoIP traffic and increasing packet loss until MOS < 3.0 was reached
- The second test used two underlying links of 100 Mbps where loss varied across one of the two links until MOS < 3.0 was reached
- The third test used two underlying links of 100 Mbps where loss varied equally across both links until MOS < 3.0 was reached

Key Findings of the Tests

- **Low-loss high availability.** Without the High Availability link bonding policy enabled, a poor end user voice experience occurs with packet loss as low as 2% loss on a single underlay link. But with the HA bonding policy enabled, good voice call quality is sustained with up to 6-7% loss on a single link.
- **Strong connections despite high loss.** Even when an Internet broadband link experiences 40% loss, the end user sees only good quality service as a result of path conditioning implemented by the HA bonding policy which counteracts packet loss and service blackouts.
- **Quality service with even 55% packet loss.** The advanced capabilities of EdgeConnect provide quality service when over half the underlay link traffic is lost, and the end user experiences no voice service interruption or degradation.

The EdgeConnect SD-WAN solution offers tailorable, policy-driven application performance to enterprise networks over any transport, including consumer broadband. EdgeConnect proved the impressive ability to build a High Availability WAN for reliable high-quality VoIP performance, even under significantly degraded WAN transport conditions. Based on our observations, we proudly award the Silver Peak Unity EdgeConnect SD-WAN solution the ***Miercom Performance Verified*** certification.

Robert Smithers
CEO
Miercom

Product Tested

The Silver Peak Unity EdgeConnect SD-WAN solution (https://www.silver-peak.com/products/unity-edge-connect) consists of EdgeConnect appliances and Orchestrator.

A family of EdgeConnect hardware appliances is offered, with varying capacities, interfaces, and redundancy options, as well as a virtual appliance that can be provisioned on a VM into the existing LAN/WAN facilities. Each EdgeConnect appliance continuously monitors throughput, packet loss, latency and jitter of all underlying WAN transports. In this testing, we used the "extra small" EdgeConnect model, EC-XS running software version 8.1.7, designed to connect a small to medium-sized branch office with one or more WAN services. The unit supports an aggregate bandwidth of 2 to 200 Mbps, up to 256,000 concurrent connections and four RJ-45 interfaces for LAN and WAN links (10/100/1000 Mbps). Other EdgeConnect appliance models scale to 10 Gbps of aggregate bandwidth, supporting copper and fiber interfaces up to 10 Gbps.

Silver Peak describes the performance objectives for a group of applications as the "business intent." Unity Orchestrator provides the central management interface for defining Quality of Service (QoS) and security parameters for a business intent overlay. The Orchestrator also provides a central console for overall SD-WAN management, monitoring, reporting, and troubleshooting. Multiple overlays with different characteristics can be defined, but for this set of tests, we focused on measuring the voice quality of a single overlay across one or two underlays (WAN transport services).

Application performance delivered by the bonded link before and after error correction was also monitored; a bonded link is a logical link comprising two or more WAN transport services. Based on the Access Control List (ACL) applied and the business intent overlay, EdgeConnect makes traffic steering decisions on the first packet in real-time.

A business intent overlay in addition to voice, can support:

- Real-time traffic applications – such as VoIP, streaming video, WebEx or Skype – with the fastest possible, low-delay delivery
- Transport of specified user traffic through high-performance tunnels, or limited WAN access of certain groups of users, such as guests on a Wi-Fi VLAN
- Internet breakout at the branch site; cloud-based application traffic does not need to be backhauled to the data center, and EdgeConnect appliances can connect users to trusted SaaS-based applications directly over the Internet based on pre-determined security policies
- Application acceleration on a per business intent overlay basis with the optional Unity Boost™ WAN optimization software performance pack

Silver Peak network overlays allow application policies to easily be configured for how applications are routed, prioritized and treated as they traverse the WAN. For example, overlays can be defined to support:

- **Real-Time Traffic**: Applications such as Skype and WebEx to name a few can be placed in a Full Mesh logical network with multiple paths using a High Availability link bonding policy using no Boost for WAN optimization.
- **Enterprise Applications**: Oracle, SAP, Exchange and so on configured in a hub-and-spoke logical network, using multiple paths, using a High Throughput link bonding policy with Boost WAN optimization applied to accelerate application performance.
- **Web Traffic**: Trusted web and SaaS applications such as Office365, Box, Salesforce can be automatically steered directly to the Internet with a failover policy to backhaul traffic if the Internet connection fails while less-trusted, unknown or suspicious web traffic can be automatically directed to more advanced cloud-based or data center-hosted security services and infrastructure.

The testing applied in this report exercised the High Availability link bonding policy of the EdgeConnect SD-WAN solution. This feature sends traffic across one link and Forward Error Correction (FEC) packets down the other link. "Path conditioning," which includes FEC and Packet Order Correction (POC), accounts for any loss or out-of-order packets to deliver high-quality application layer transmission. During service blackouts, this HA failover is instantaneous and allows for an uninterrupted overlay service – voice calls in these tests.

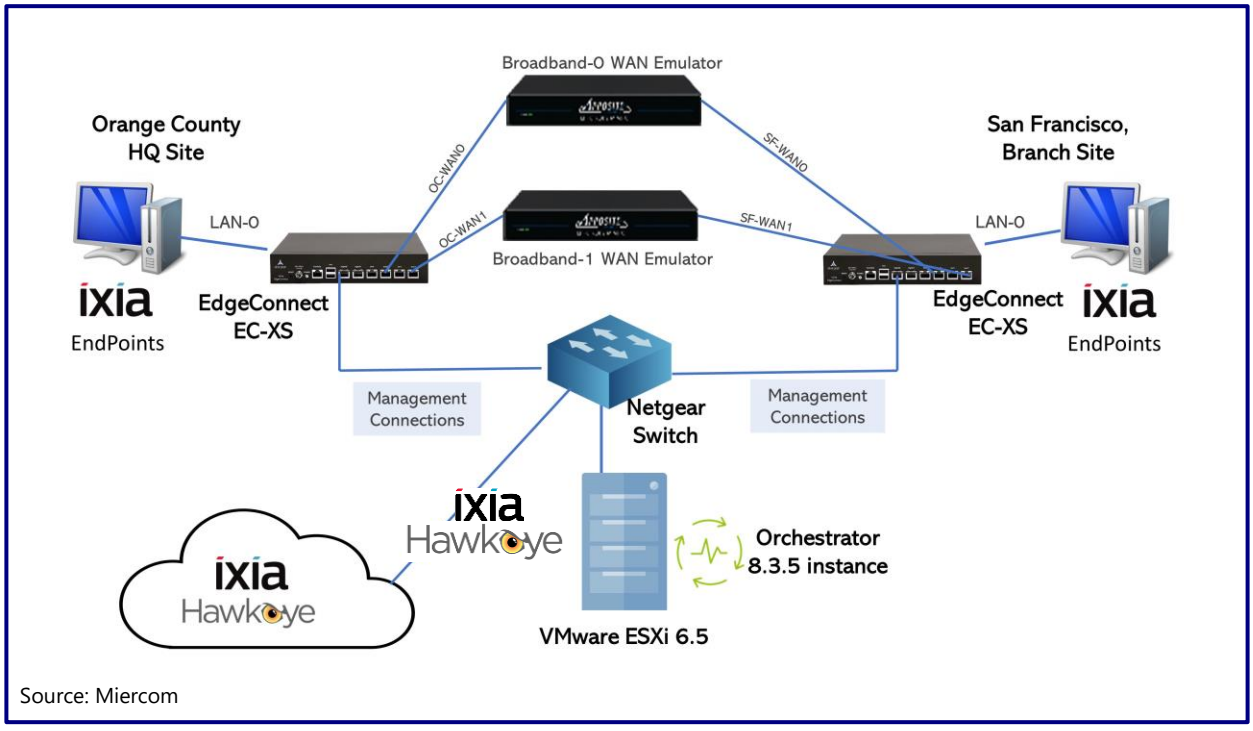
The testbed setup and test cases are described in the following sections.

How We Did It

A test bed network was configured between two desktop PCs connected to EdgeConnect EC-XS appliances. The EdgeConnect appliances were connected through two WAN services in a simulated configuration, as shown below. Apposite Technologies WAN emulators acted as links capable of dropping packets at specified percentages for testing purposes.

One end of the test network was designated the OC (Orange County) headquarters/data center site, and the other designated SF (San Francisco) branch office. This set-up was designed to show a small branch office (SF) that connects with headquarters (OC) via these WAN facilities. The two facilities each operated at 100 Mbps, yielding 200 Mbps of aggregate bandwidth, with 50 milliseconds (ms) of latency. Two underlay links were used in testing – both broadband links, with less loss applied to one broadband link labeled Broadband_0 in the diagram below and the other Broadband link labeled Broadband_1 treated as the more lossy network. Otherwise, the links had the same characteristics. Note that in practice, both links could be broadband, MPLS, 4G/LTE or any combination thereof.

Test Bed Diagram



Source: Miercom

The above configuration enabled the testing of bonded links – the concept of the Silver Peak SD-WAN solution where multiple WAN services are bonded together to support aggregate bandwidth and High Availability (HA) handling. A virtualized Dell PowerEdge T430 server ran

VMware ESXi v6.5 and hosted the Orchestrator management software. Two Apposite Technologies LinkTropy Mini-G WAN Emulators set loss percentages across WAN links for each test case.

All tests were configured via Ixia Hawkeye which continuously ran test traffic and changed line loss parameters. After letting traffic settle for two minutes, the MOS was measured over the next five minutes – a window set in the Hawkeye user interface. The MOS average was provided by the Hawkeye and recorded for varying percentage loss scenarios.

Overlays. Silver Peak Orchestrator was used to set up a High Availability link bonding policy which includes Path Conditioning to the overlay. This entails several additional special processing features:

- **Adaptive Forward Error Correction (FEC).** When FEC is enabled, Silver Peak periodically sends error correction packets (parity packets) to reconstitute lost packets at the far end of a WAN link, avoiding the delays that come with multiple round-trip retransmissions. This enables the WAN to readily recover from packet loss, regardless of the reason.
- **Real-time Packet Order Correction (POC).** To avoid retransmissions that occur when packets arrive out of order, Silver Peak software re-sequences packets across all IP flows at the far end of a WAN link. By doing this in a dedicated device (the EdgeConnect appliances), Silver Peak can better handle high volume, high throughput data streams with minimal added latency.

Tunnel Bonding. An advantage of the Tunnel Bonding approach is that all available bandwidth of multiple WAN links can be used. Frequently, with typical router-based WAN configurations, just Path A or Path B is used, so one path or the other is in a standby mode and remains passive.

In each of the test cases, two WAN emulators were used to insert traffic loss across the tunnels. The loss percentage was set via the LinkTropy Mini-G WAN Emulators: one for the WAN traffic over the Broadband_0 links, and one for the WAN traffic over the Broadband_1 links (see below). The reason for using two WAN emulators was to be able to show asymmetrical traffic going upstream and downstream.

Percentage of loss was applied to one or more links until the MOS decreased below 3.0 using the following test cases:

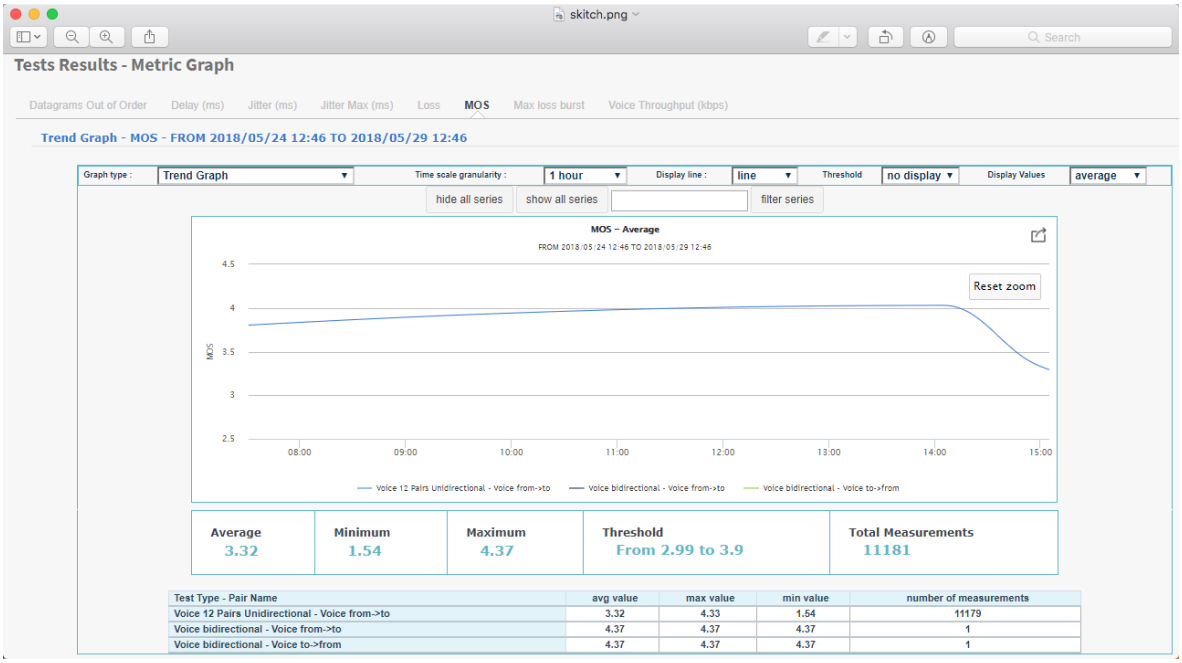
1. Baseline Voice Performance Over Single Broadband Service
2. Two WAN Services with One Link Impaired
3. Two WAN Services with Both Links Impaired

Results were validated within 0.05 percent of previous test runs, and the test wherein the MOS limit was reached was run twice to verify the exact point of unsatisfactory quality. Numbers were consistent across these validations.

Orchestrator Live View

As each test was run, the bandwidth, loss, and latency were monitored on the underlays and overlay using the Orchestrator Live View to observe real-time metrics of the traffic. The Live View interface permits the user to monitor packet loss running from each side of the WAN communication and to switch traffic monitoring direction if desired. In the Orchestrator Live View, graphs are sectioned as Bandwidth, Loss and Latency over time. Each graph section has three blocks of data which represent the overlay link, and the two underlying broadband links. It is expected for loss in underlay links to not be reflected in the overlay link due to error correction provided by the HA link bonding policy. Loss on either or both underlays does not appear at the voice endpoint.

Ixia Hawkeye Graph of MOS Average



Source: Miercom

This graph from the Ixia Hawkeye application shows the graph of the MOS over the selected time range of one hour. In the test, a range of five minutes was selected for the length. The "Average" field was taken as the 5-minute average MOS for our testing.

Test Tools

Apposite Technologies LinkTropy Mini-G WAN Emulators acted as simulated WAN links with modifiable parameters – bandwidth, latency and loss – to determine real-world performance.

JPerf 2.0 is a Java-based GUI network testing tool similar to Iperf. Test results are automatically graphed and presented in a format that is easy to read. JPerf was used to simulate the other voice background traffic.

Ixia Hawkeye is a performance monitoring tool that determines end user experience, measured as average MOS, based on node-to-node and real service testing. This product generates broadband services and background traffic, initiates VoIP calls and introduces packet loss to one or both service links.

VMware ESXi is a virtualization software for running management and performance test tools.

Test 1: Baseline Voice Performance Over Single Broadband Service

This test served as a baseline, demonstrating optimal VoIP performance across a single broadband service link. Packet loss was incremented across the broadband link named Broadband_0 until an unsatisfactory quality was reached (MOS below 3.0) as 100 Mbps of VoIP and background traffic was running. A single underlay was configured with the High Availability (HA) link bonding policy. FEC automatically kicked in after loss was detected on the underlay link.

To demonstrate the effect of path conditioning on the underlay, we first compared a single link without path conditioning and injected 1 and 2% loss. Next, we analyzed a single link with path conditioning automatically enabled once loss was detected and measured voice quality.

Voice quality was measured using a Mean Opinion Score (MOS) – and algorithm-based assessment on a scale of 0 to 5, where 5 represents the highest quality – reported by the Ixia Hawkeye. MOS is an estimate from an algorithm based on the human experience, and therefore an "opinion," which helps assess the effects of WAN service impairment on VoIP communications.

The following test parameters were used for Test 1, Test 2 and Test 3:

- 12 simultaneous bi-directional calls
- Voice call bandwidth of 768kbps per direction
- G.711 codec
- 50ms latency
- HA bonding policy applied
- Percent of packet loss on unimpaired links varied according to test
- Tests terminated when MOS < 2.99
- Tested crossover values verified by additional test runs

The Live View images below show a side-by-side comparison of a single underlay with 100 Mbps of traffic, without path conditioning and with path conditioning. The traces display the differences that the error correction and order correction mechanisms have on the overlay. A single underlay connection for 1 and 2% loss was measured below.

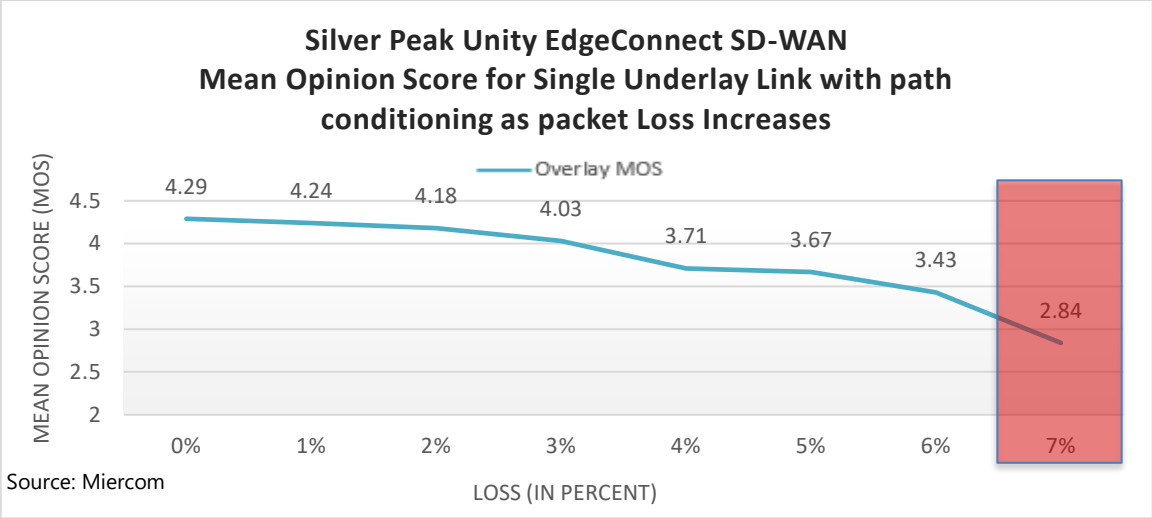
Source: Miercom

Underlay with FEC ***Underlay without FEC***

Top Bar (Bandwidth): 100 Mbps of bandwidth is completely consumed in both trials.

Middle Bar (Loss): Without path conditioning enabled (right), the underlay and overlay both show 1, and then 2%, loss. This loss shows in the higher layers of the network, requiring reconnections for lost messages. The chart with path conditioning enabled (left) shows the same loss in the underlay but error-corrected in the overlay. No loss or retries were required by the overlay.

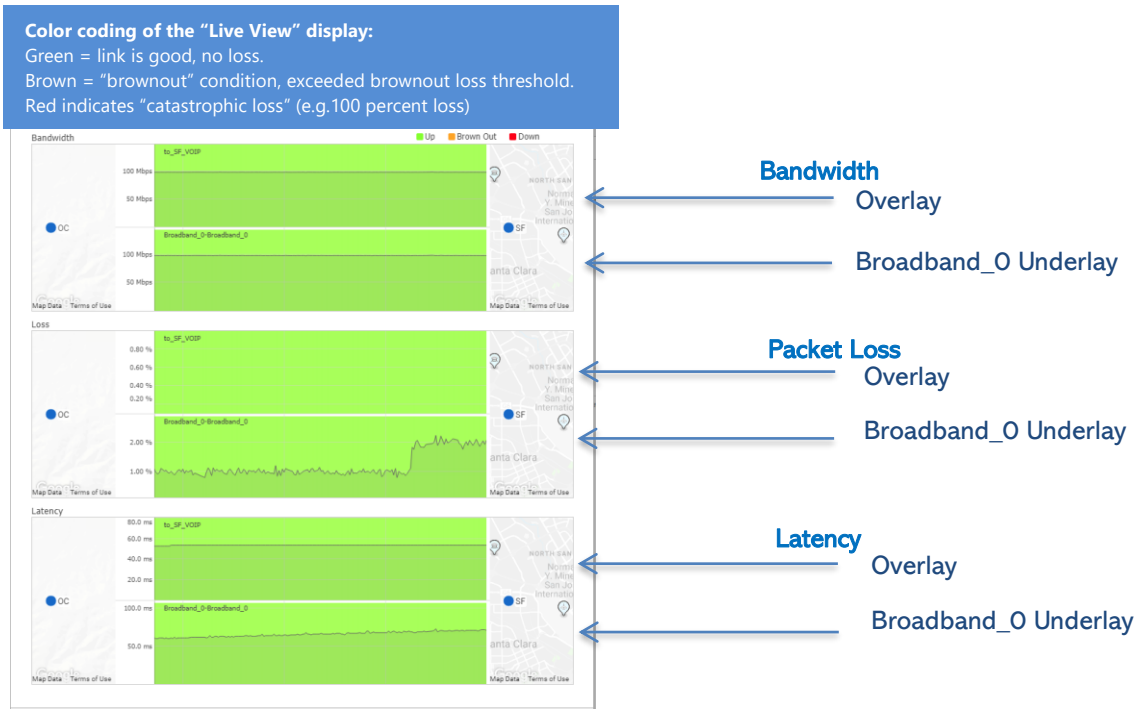
Bottom Bar (Latency): The overlay and underlay show the current latency detected on the network. The image showing the underlay without FEC has a higher latency due to queue overflow. In testing default queue sizes were used.



Source: Miercom

With 100 Mbps of combined VoIP and other background traffic, a single broadband underlay link labeled Broadband_0 could sustain up to a 6% data loss while providing satisfactory voice quality when path conditioning was enabled. This was the baseline for the following tests. Once packet loss reached 7%, voice quality suffered and become unsatisfactory with a MOS of 2.84.

Orchestrator Live View: Single Underlay Link Impaired

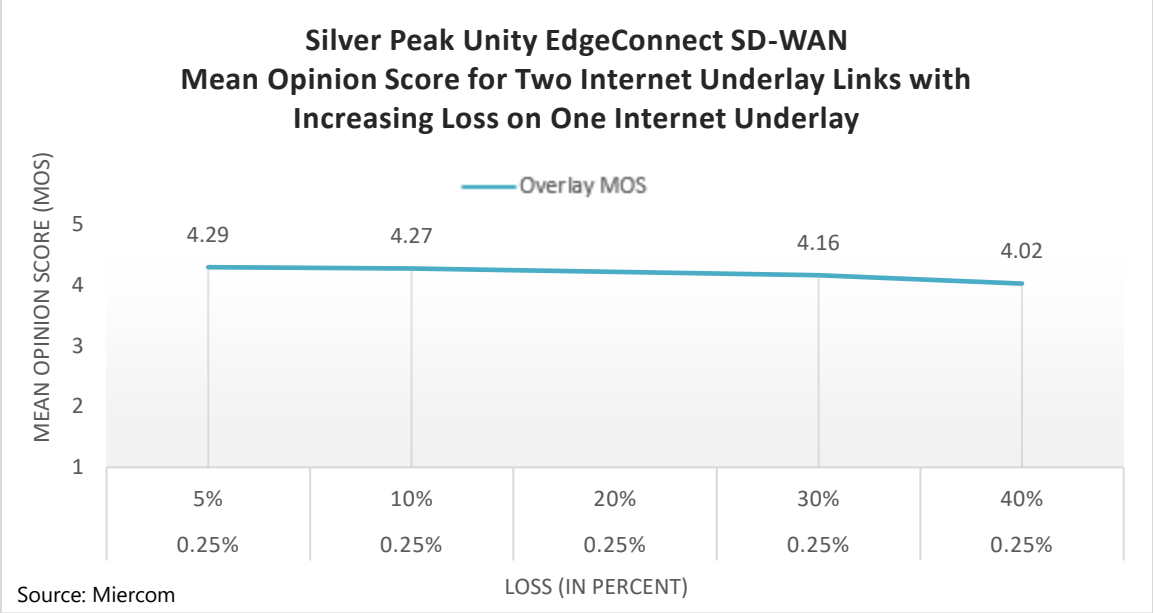


Source: Miercom

The broadband underlay labeled Broadband_0 shows approximately 1 and 2% percent packet loss, while the VoIP overlay (to_SF shows no loss. As expected, the VoIP application overlay with path conditioning enabled exhibits no loss despite the loss on the physical link.

Test 2: Two Broadband Services with One Link Impaired

In this test, two broadband service links were used with the EdgeConnect HA tunnel bonding policy enabled to correct for dropped packets. One link was impaired up to 40% packet loss and the second underlay link was impaired with 0.25% packet loss to simulate a healthy WAN service, to test asymmetrical loss patterns and to demonstrate the EdgeConnect's ability to adapt and correct for packet loss. Many applications, such as email, will begin to fail once loss exceeds 5 percent.

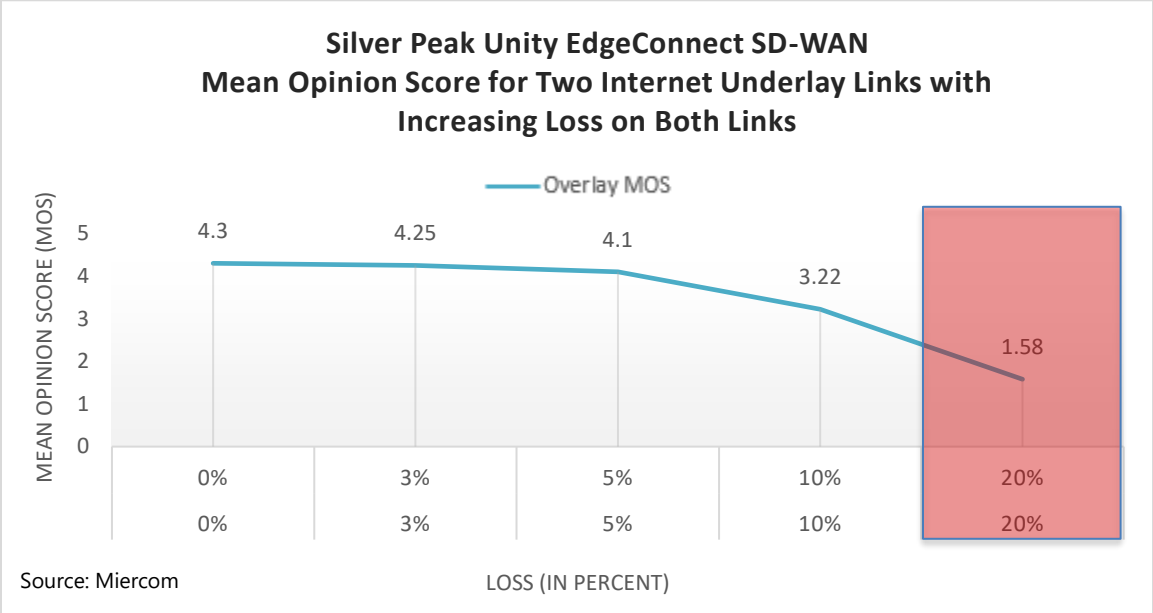


Source: Miercom

The configuration approaches a MOS of 4.0 very slowly since the broadband link labeled Broadband_0 is very reliable, with a loss of 0.25%. Even as loss increases on the impaired Internet link from 5 to 40%, the healthy broadband link is capable of handling the traffic. Compared to the baseline test, EdgeConnect does not experience degraded quality despite significant impairment of more than 40% packet loss to one of the underlay links. With the EdgeConnect HA tunneling policy applied, high packet loss shows no effect on voice quality.

Test 3: Two Broadband Services with Both Links Impaired

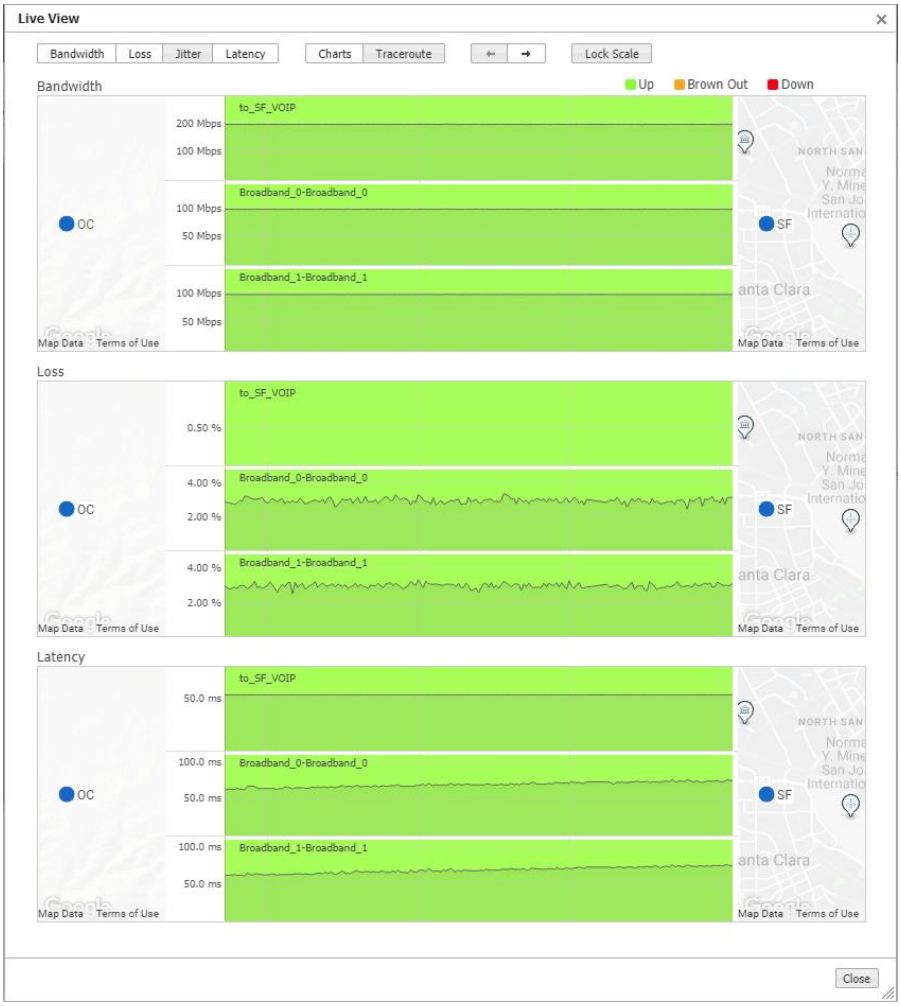
In this test, two broadband services experience high packet loss to demonstrate the capability of the EdgeConnect HA mode to overcome the effects of packet loss and deliver satisfactory voice call quality. Both links are impaired with the same increasing amount of packet loss until MOS becomes unsatisfactory – less than 3.0.



Source: Miercom

Loss on both underlying links is increased at the same rate up to 20%. Between 10 and 20% loss, MOS fell below business-acceptable performance. This amount of loss on both links simultaneously is unusual and results in EdgeConnect issuing alerts to the network administrator. Since the overlay continues to function, the end user will not experience interruption or service degradation despite heavy loss on both underlay links because of the EdgeConnect's HA tunnel bonding policy with path conditioning.

Orchestrator Live View: A Baseline of Both Underlay Links Impaired at 3% loss, 50ms Latency

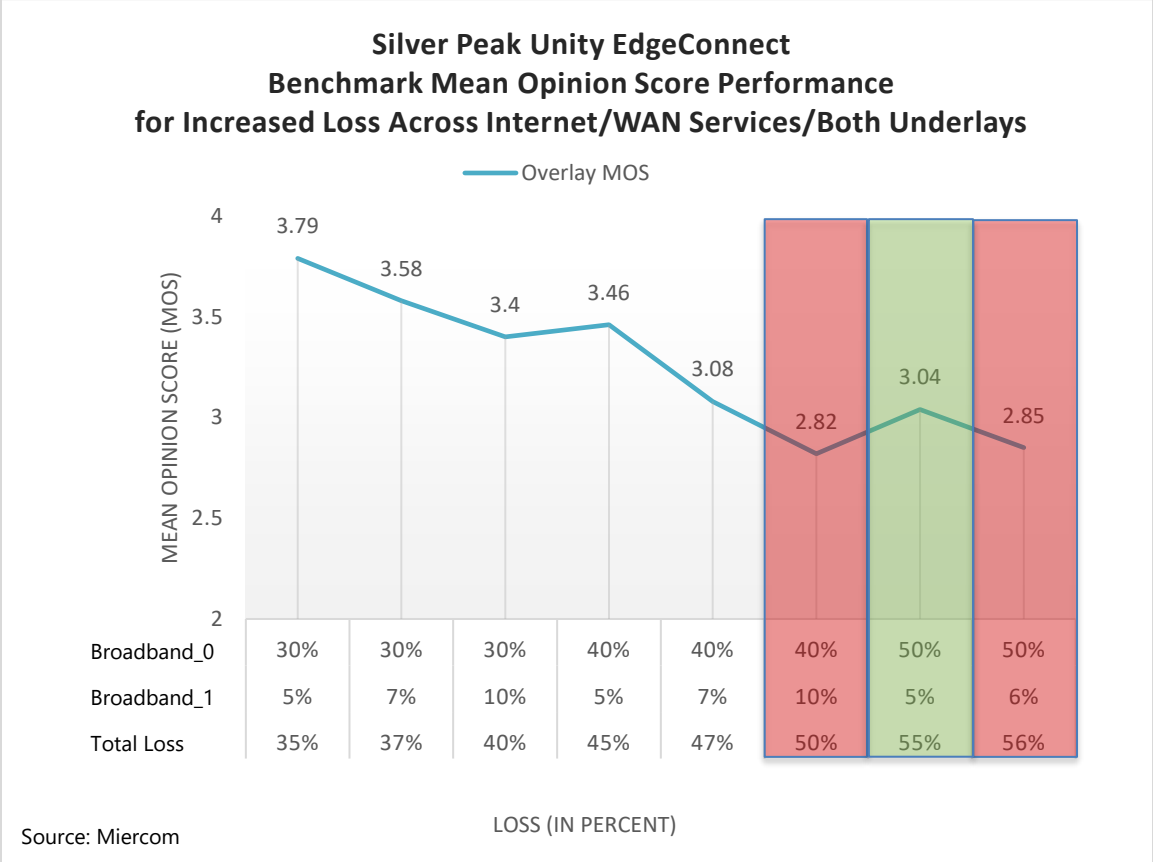


Source: Miercom

The Live View chart above represents a baseline measure from the previous image using one of the test points. In Live View, the loss and latency are measured on each broadband underlying links to 3% and 50ms latency while maintaining a MOS score above 4.30. The loss and latency on the underlays do not affect the overlay's channel and the end user experiences no difficulty with the voice quality.

Benchmark Performance of Increased Loss Across Both Underlay Links

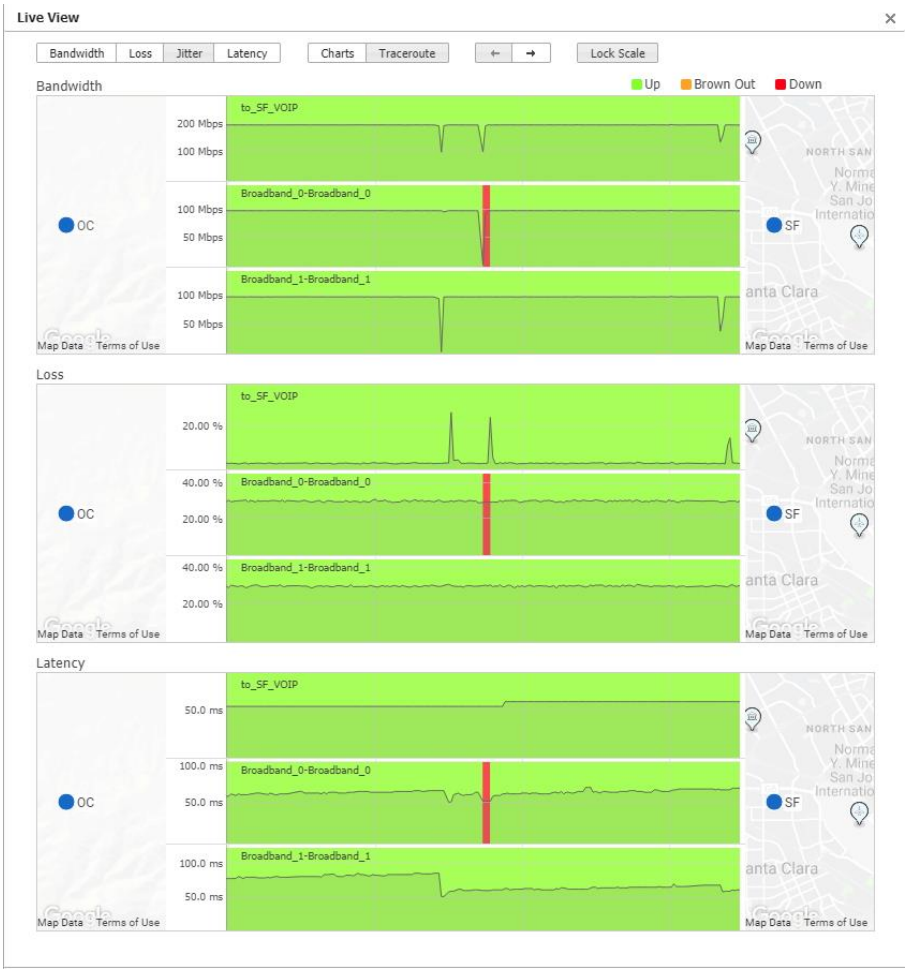
This benchmark performance test demonstrates how the HA with path conditioning handles total loss across both links for up to a nearly 50 percent loss.



Source: Miercom

Loss was increased on the Internet Link from 30 to 50% and varied from 5 to 10% on the Broadband_0 link. The MOS fell below 3.0 for two instances of Broadband_0/Broadband_1 link impairment: 40/10% and 50/6%. The total loss was 50 and 56%for both links. The overlay MOS was 2.82 and 2.85, respectively, and was what the end user would experience during these high loss scenarios on both underlays. At an impressive 50% loss on the Internet link, and 5% loss on the Broadband_0 link – a total of 55% underlay link loss – the overlay sustained satisfactory MOS of 3.04, showing no service interruption or degradation to the end user because of the EdgeConnect HA link bonding policy.

Orchestrator Live View: Severe Loss on Both Underlay Links

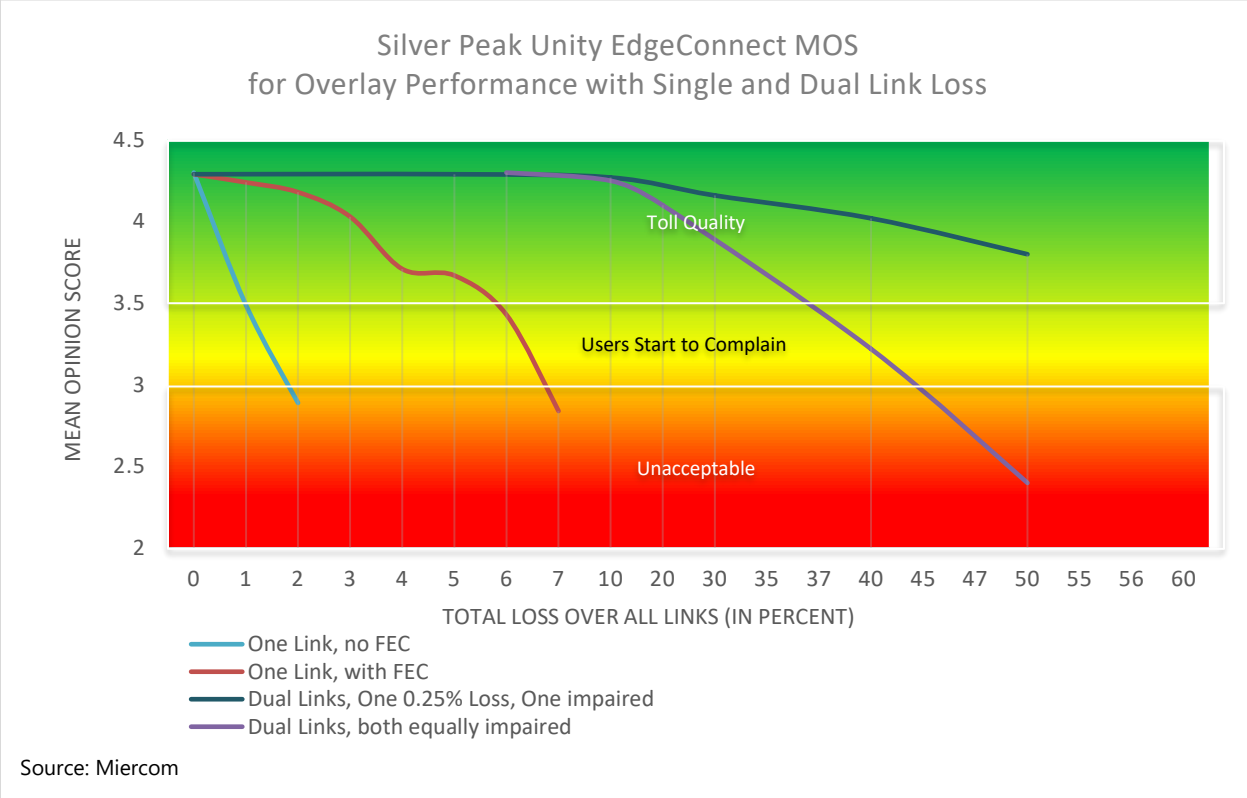


Source: Miercom

LiveView displayed red bars in the underlay links to indicate complete data loss for a few moments. This loss is not seen in the overlay, as it was corrected by the path conditioning feature which reconstructed and reordered lost packets. The overlay bandwidth, loss and latency are what the end user would experience, and this was satisfactory because of the advanced EdgeConnect SD-WAN solution.

Test Summary

This chart combines all test results to demonstrate the EdgeConnect SD-WAN solution's ability to support high quality voice communication (MOS > 3.0) across the tested configurations above 40% loss.



Source: Miercom

The EdgeConnect SD-WAN solution supports high quality voice transmission for up to 7% loss on a single underlay link, but when dual underlay links are used with HA tunnel bonding and auto path conditioning, business-quality VoIP communications are possible into the 40 to 50% loss range despite severely impaired broadband services.

The Silver Peak Unity EdgeConnect advanced SD-WAN solution provides quality voice communication in times of peak congestion or a complete service blackout condition using its High Availability tunnel bonding and path conditioning. Based on our testing, even with relatively less reliable consumer-grade Internet, the EdgeConnect SD-WAN solution can tolerate upwards of 20% loss on both connections simultaneously. Customers can gain the benefits of the HA bonding policy and path conditioning by deploying two or more broadband services. To achieve business-quality VoIP across broadband, we find using an advanced SD-WAN solution such as EdgeConnect can deliver valuable service while potentially lowering WAN transport costs by using active/active broadband services.

About Miercom

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Private test services available from Miercom include competitive product analyses, as well as individual product evaluations. Miercom features comprehensive certification and test programs including: Certified Interoperable™, Certified Reliable™, Certified Secure™ and Certified Green™. Products may also be evaluated under the Performance Verified™ program, the industry's most thorough and trusted assessment for product usability and performance.

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