# APPOSITE
## TECHNOLOGIES

# TESTING SD-WAN WITH REAL-WORLD CONDITIONS

## BACKGROUND

Distributed enterprises are saving money on network costs while increasing network reliability by taking advantage of new SD-WAN products. An SD-WAN network connects corporate headquarters and datacenters with local offices and SAAS applications through multiple WAN links, usually combining an expensive but highly reliable MPLS network for high priority data with one or more low cost Internet broadband connections for less critical or time sensitive data. Other network technologies such as 4G cellular data or satellite can be including for redundancy and back-up. By combining multiple WAN links with differing characteristics, SD-WANs can provide higher reliability and performance than a single network, while reducing costs by sending the majority of the traffic over Internet tunnels. Many SD-WAN products then layer on WAN acceleration techniques such as data compression and deduplication to optimize

application performance while reducing bandwidth requirements.

SD-WAN controllers consequently employ highly complex algorithms to decide which traffic to direct over which link and when to switch traffic from one link to another. These algorithms are proprietary to each vendor and can vary considerably. Products also offer markedly different level of functionality, application acceleration capability, product maturity, and cost. It is therefore imperative for SD-WAN vendors to test their algorithms under realistic customer network conditions, and for SD-WAN buyers to compare products under conditions that match their own network to select the optimal solution for their needs.

WAN emulators simplify the testing and evaluation of SD-WAN systems by replicating real-world network conditions to allow the systems to be tested in the lab in a repeatable, realistic network environment.

## WHAT IS A WAN EMULATOR?

Application performance is impacted not only by the availability of sufficient bandwidth, but by the latency caused by the distance between the sites and packet loss caused by signal errors and congestion. Other network impairments such as short outages, reordered packets, packet fragmentation, etc. can also have a huge impact on application usability. Whitepaper 1 For example, a typical file transfer over a high-speed 1 Gbps link may be limited by cross-country latency of 120 ms to a throughput of less than 100 Mbps, only 10% of the available bandwidth. If only 0.1% of the packets, or one out of every thousand packets are lost over the network, throughput is further reduced to only 5 Mbps.

A WAN emulator replicates the bandwidth, latency, loss and other conditions of the network so that application performance can be validated in the lab. Essentially, packets that pass through a WAN emulator appear exactly as if they traveled across the WAN. This allows application performance between two sites to be tested simply by attaching a client and server device (or network of devices) to the two ports of the WAN emulator and setting the conditions to match the real-world network. Application throughput, responsiveness, and quality can then be evaluated and measured.

Many WAN emulators also include the ability to profile live network conditions and automatically reproduce those dynamically changing conditions within the test system.

## TESTING SD-WANS WITH A WAN EMULATOR

By replicating the real-world network in the lab, WAN emulators are an invaluable tool to test and optimize SD-WAN systems and optimize their configurations. Figure 1 shows a typical SD-WAN network connecting a local office to the corporate data center and internet SAAS providers.

In this example, the local office has three separate network connections, an MPLS network for high-priority traffic, a low-cost broadband Internet connection for lower priority traffic, and a 4G cellular data connection for backup.

SAAS servers can be reached directly over the Internet link or through the wireless network without having to connect through the data center.

This SD-WAN example can be simulated in the WAN emulator by configuring three separate paths, one for each network connection, as shown in Figure 2. Initial WAN conditions can be set to determine application performance under normal conditions. The WAN conditions can then be varied dynamically to see how the SD-WAN system reacts to network outages, congestion, excessive packet loss and other factors and measure how they affect application performance.



Wireless: 171ms delay, 2.9ms jitter, .25% loss
Internet:  94ms delay, 2.4ms jitter, .1% loss
MPLS:      60ms delay, .3ms jitter, .01% loss
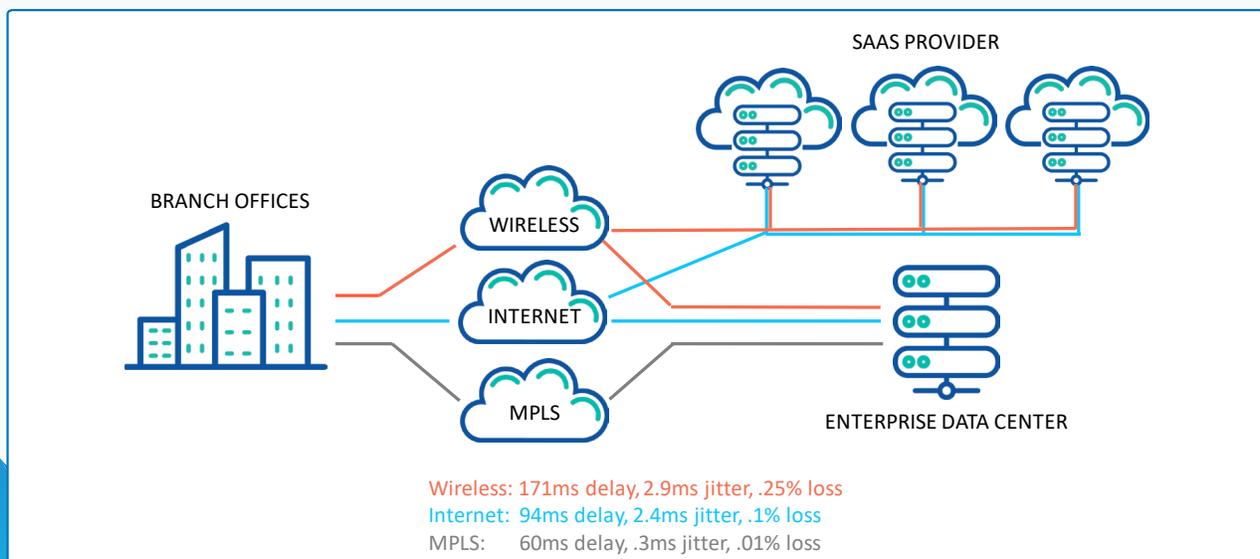
*Figure 1. Typical SD-WAN Configuration*
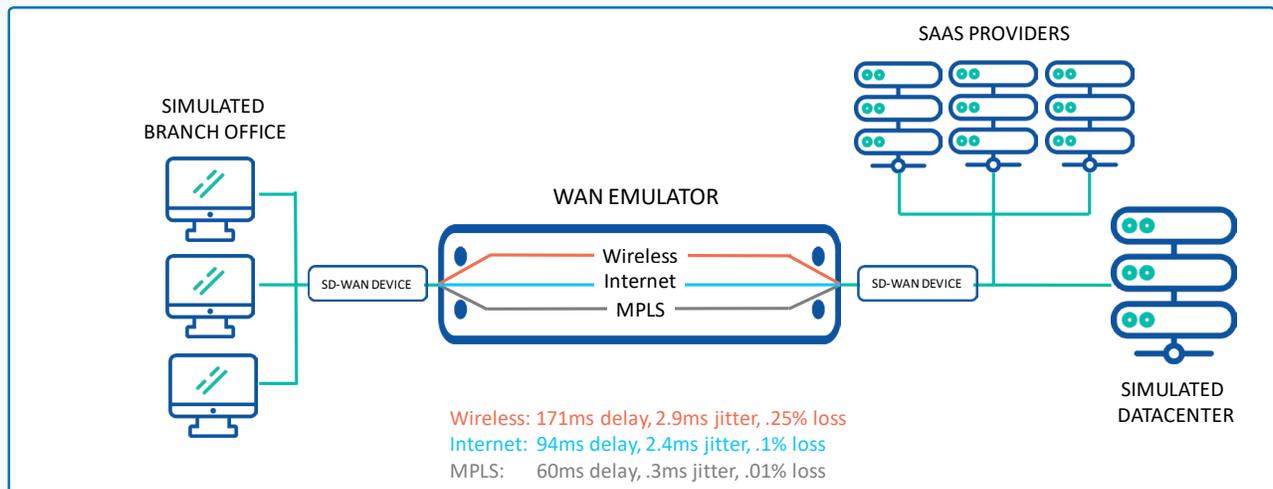
*Figure 2. Simulate SD-WAN using a WAN Emulator*

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MPLS: 60ms delay, .3ms jitter, .01% loss

## SD-WAN IMPAIRMENT TESTING

Network impairments are introduced on the test network using a WAN emulator to test how SD-WANs respond to network conditions through link failover, packet steering, and prioritization, and how those changes impact the application end user experience. Test conditions include:

- **Increased latency and jitter.** Latency and jitter are increased in the WAN emulator for the primary link beyond the SD-WAN programmed threshold. The SD-WAN controller should detect the impairment and determine whether it is a momentary blip due to congestion or a longer term degradation and decide whether to switch the traffic to the other the WAN links. The controller then needs to be able to detect the return to nominal conditions and switch traffic back to the primary link.

As shown in Figure 3, on a second-by-second basis, latency often varies by tens or hundreds of milliseconds on typical Internet links and by even more on wireless networks. Separating the signal of a significant and detrimental increase in latency from the noise of regular variability can be challenging. Since switching traffic from one path to another can cause detrimental performance impacts, the SD-WAN controller needs to maintain a delicate balance between reacting quickly to network impairments improve performance and excessive

path switching that decreases performance.

- **Network Outage/Packet loss and Link Failover.** SD-WAN controllers must determine when links are down and failover to secondary links or back-up connections. To test these algorithms, the WAN emulator is used to apply packet loss or create network outages for of varying lengths.

Detecting whether a physical link is up or down is simple, but when an intermediate hop somewhere in the network loses a few consecutive packets, determining whether this is due to a link outage or just momentary queue overflows is difficult. Link outages might be only a few milliseconds in length, which could be ignored if they happen only once, but recur regularly, causing serious performance degradation. Links may not be fully down but simply experience high loss rates or cause data corruption. Deciding when to switch to a failover link can be a complicated decision, and determining when the outage event is over to switch back to the original link is even more difficult. Again, since switching traffic to a different link carries its own performance cost, the end user experience can be hurt by either not switching quickly enough or switching paths too frequently.
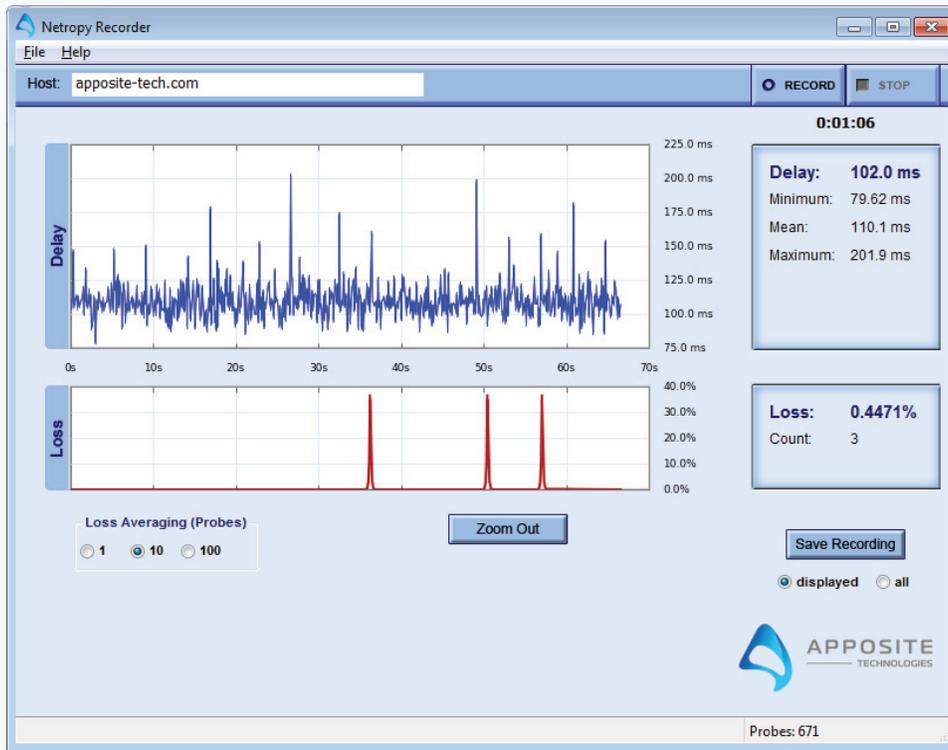
*Figure 3. Second-by-Second Latency of Cross-Country Internet WAN*

- **Congestion.** When congestion occurs on the network, many SD-WAN controllers prioritize traffic to optimize the performance of important and time-sensitive data. The WAN emulator is used to simulate bandwidth constraints on each link, as well as background traffic that can cause congestion to test the effectiveness of this SD-WAN functionality.

- **Link aggregation.** The bandwidth on multiple links between the same destinations can be bonded to aggregate available capacity. However, if packets from the same flow travel over different links, they will arrive out of order which can have a disastrous effect on application performance. If this feature is part of the SD-WAN system, sufficient traffic should be generated to check application performance when traffic is split between multiple paths.

- **Automation capabilities.** SD-WAN controllers may allow user-programmed responses to network impairments. For example, access to Netflix and Facebook might be limited during periods of network congestion. WAN emulators can be used to change

or create congestion or other triggering events to ensure proper operation of these features. Figure 3. Second-by-Second Latency of Cross-Country Internet WAN Connection 4 Figure 4. Example of traffic monitoring with Netropy WAN Emulator

- **Application aware routing.** Many SD-WAN controllers can prioritize traffic based on application and protocol type, filtering the traffic to different links based on costs, performance, and capacity. The WAN emulator can be configured to match the conditions of the different links to validate acceptable end user experience for the many different applications that users depend on.

- **Application acceleration.** Many SD-WAN systems offer a variety of application acceleration and WAN optimization techniques including compression, deduplication, caching, TCP optimization, and applicationspecific proxying. The WAN emulator allows users to test the efficacy of these optimizations for different applications and a variety of real-world network conditions.
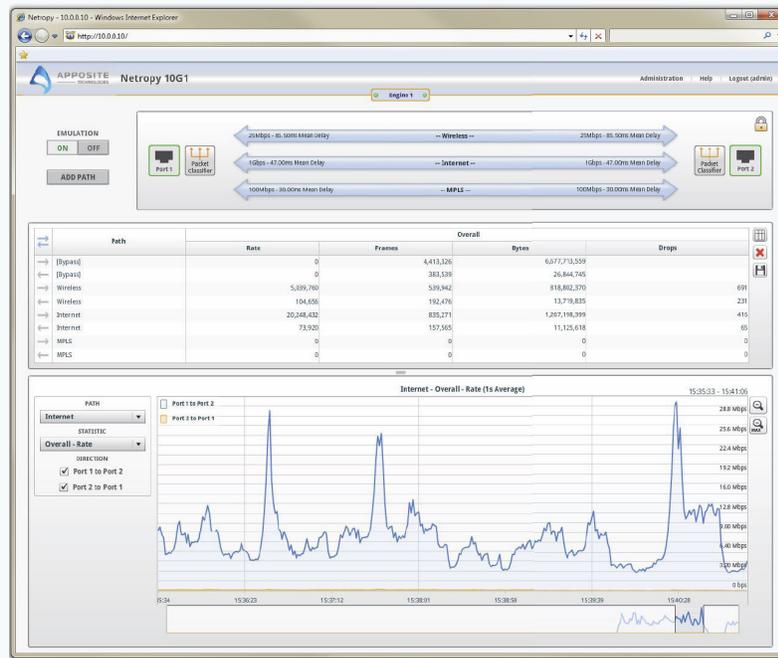
*Figure 4. Example of traffic monitoring with Netropy WAN Emulator*

## CONCLUSION

SD-WANs enable optimal use of WAN links that connect the enterprise to increase capacity and reliability while reducing costs. However, SD-WANs are highly complex systems managing mission-critical network. Extensive testing is required to select the SD-WAN system for the user's specific network conditions, application mixture, and budget, and ensure proper operation during both anticipated and unanticipated situations. WAN emulators are a critical test tool to benchmark SD-WAN systems under real-world network conditions products prior to vendor selection and to perform reliability testing and optimization prior to deployment.

## ABOUT APPOSITE TECHNOLOGIES

Apposite is the leader in WAN emulation. Apposite's Netropy and Linktropy WAN emulators simulate the bandwidth, latency, loss and other network conditions to validate application performance in a repeatable test environment. Distinguished by industry-best ease-of-use and unmatched value, Apposite's WAN emulators are widely utilized by SD-WAN equipment developers and enterprise IT teams to benchmark and optimize the performance of SD-WAN systems under real-world conditions.

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