NETWORKS

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Building a Software-Defined WAN

BUILDING A SOFTWARE-DEFINED WAN

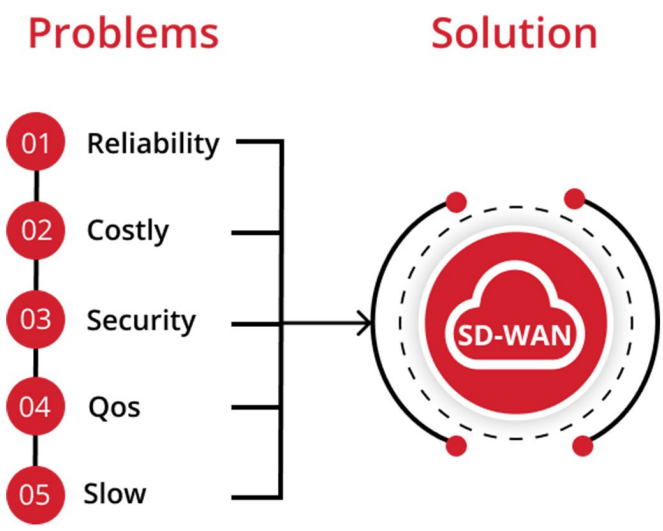
Businesses Rely on Branch Offices or Remote Employees to Serve Customers, To Be Near Partners and Suppliers and to Expand Into New Markets. As Application and Desktop Virtualization Increase or Applications Move to the Cloud, IT Managers Face the Challenge of Providing These Applications Without a Performance Penalty to Branch and Mobile Users. Our Bonded Internet and SDWAN Can Help You Effectively and Economically Increase WAN Throughput While Accelerating Enterprise Applications and Ensuring the Performance and Availability of Mission Critical Applications.

Your WAN is Stressed

Productivity plummets when virtual desktop infrastructure (VDI), voice over IP (VoIP) and video conferencing connections disconnect. Employees complain when cloud-based applications take too long to respond or time out. Work comes to a halt when employees lose access to ERP, CRM and other enterprise applications. Sales stop and customers leave the store when POS terminals lose their connections. Today enterprises rely on wide area networks (WANs) to support an ever-growing number of bandwidth-intensive business critical applications. Because these applications are used to "run the business," they demand high reliability and quality of service. When they slow down for even a few seconds, employees notice and complain. Unfortunately, IT staff face a dilemma when they try to improve the reliability and capacity of their WANs. Multiprotocol label switching (MPLS) is reliable and provides fairly consistent performance, but adding capacity can be expensive. Internet connections via broadband technologies such as cable and DSL are much less costly, but reliability and performance are inconsistent and there are security concerns. WAN optimization products accelerate performance and effectively increase bandwidth, but they can't overcome all of the issues when the underlying WAN is unreliable or unavailable.

Introducing the Software-Defined WAN

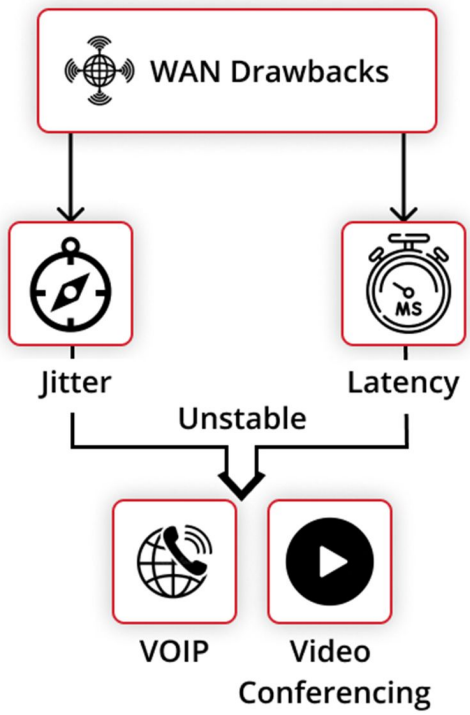
A new approach called software-defined WAN, or SD-WAN, offers a solution to this dilemma. This technology logically binds multiple MPLS and broadband paths into a single logical path. With SD-WAN, quality of service (QoS) rules, path selection and traffic shaping can be applied to ensure that high-priority applications always perform well. SD-WAN can also ensure that all bandwidth on all paths is fully utilized. In addition, critical business processes can be protected against network outages. If even a single path remains, key applications can be switched over in milliseconds and continue uninterrupted operation with no discernable impact on end user productivity.



What Can Go Wrong? A Typical Datacenter-to-Branch WAN Connection

Before examining how SD-WAN technology works, let's look at a typical situation today for networking between a datacenter and a medium-sized branch or remote office. Most traffic, including all traffic for business critical applications, is configured to run through an MPLS connection. One or two paths through the public Internet have been added, primarily for backup in case the MPLS link goes down .

What are the Drawbacks in This Arrangement?



There is a Lot of Wasted Bandwidth and Contention.The broadband paths are kept in reserve in case the MPLS link fails, or used only for a few low-priority applications. If the MPLS path reaches capacity, there is no easy way to move MPLS traffic over to the broadband connections to reduce contention on MPLS.

Failover When a Connection Goes Down Can Take Several Seconds, or Even Minutes. Even a short outage can be extremely annoying to employees, who may be forced to restart sessions or log in again, and it can result in a loss of revenue for the enterprise .

After Failover, the Performance of Critical Applications Will Be Seriously Degraded, along with all other applications using the remaining paths. With many applications competing for limited bandwidth on the backup connections, applications sensitive to latency, loss or jitter like desktop and application virtualization, VoIP and video conferencing may become unusable, resulting in additional lost business.

Adding Additional Capacity Can Be Very Costly. If the Internet connections can't provide the required reliability and quality of service for new applications, then the organization is looking at very expensive upgrades to its MPLS network.

Although MPLS Networks are Generally of Good Quality, They Can Still Experience Packet Loss, Latency and Jitter. These problems impact latency-sensitive applications, causing yet more employee frustration and lost business.

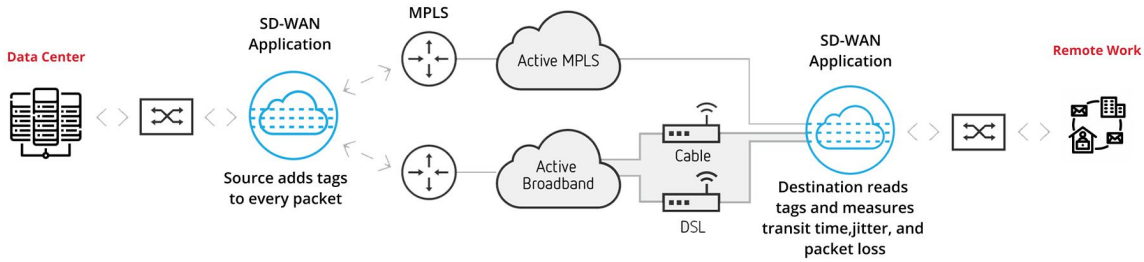
Branch Networks are Becoming More Complex, potentially with separate appliance for routing, firewall, and WAN Optimization. Multiple appliances increase the cost per branch and add complexity to maintaining and troubleshooting the branch network .

Network Administration Can Be Complex and Time-Consuming. Application traffic needs to be configured and monitored differently for each path. If paths to a remote office or user take more than one "hop" across different network types, then it is extremely difficult to manage end-to-end monitoring and quality of service.

The issues mentioned above will be greatly magnified in an enterprise with multiple datacenters and dozens or hundreds of remote offices.

The challenges will be even greater with the increasing use of cloud-based applications. Now that we've looked at the problems that are common with a typical WAN, let's look at the basic capabilities and features of a software defined WAN and then see how SD-WANs address these problems .

Our SD-WAN Appliances Measure Transit Time, Jitter and Packet Loss, Then Create a "Map" of the Performance and Health of All Paths in the WAN. This Information Is Used To Select the Most Appropriate Paths for Different Types of Traffic. Broadband Connections Can Now Be Used Actively for All Applications.



SD-WAN Basics #1: Measure and Monitor Network Paths

The most important aspect of SD-WAN technology is the knowledge it gathers regarding the underlying network connections and the intelligent decisions it makes using this knowledge. The unique power of SD-WAN is achieved by :

1. Measuring and monitoring network paths in both directions
2. Identifying and assigning priorities to applications.
3. Applying the knowledge gained from monitor ing paths to optimize the reliability and performance of network traffic.

Except with our SD-WAN application included at each location. (Later we will discuss how many benefits of SD-WAN can be gained with a SDWAN appliance at only one end, or with a virtual appliance in the cloud).The source (sending) appliance adds tags to each packet with information about the time sent and its order in the packet flow.The destination (receiving) appliance reads these tags and uses the data to measure transit time, congestion, jitter, packet loss and other information about the performance and health of the path. The appliances share this information with the controller, which uses queuing theory and predictive behavioral statistical modeling to create a "map" of all of the paths in the WAN. This information is continuously updated with information from recent packets .These techniques allow the WAN appliances to continuously measure and monitor the performance, quality and health of every MPLS and broadband connection in the WAN, then apply that knowledge to providing quality of service, path selection, traffic shaping,

SD-WAN Basics #2: Application Awareness

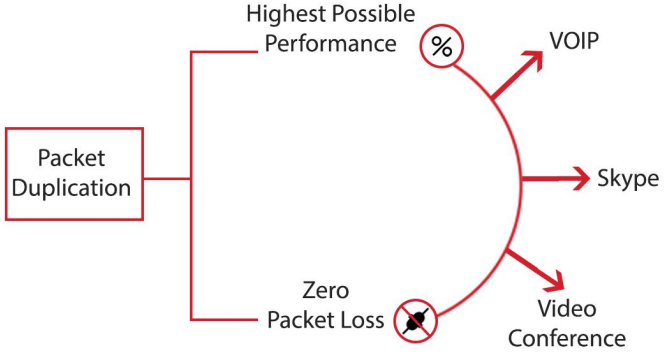
Our SD-WAN solution allows enterprise IT to make prioritization decisions for each application using very granular application classification. That ensures that the highest priority applications alway-perform extremely well, while other applications receive QoS appropriate to their priority . Each application is assigned to one of three high-level categories: "real-time," "interactive" and "bulk." Typically, high-priority applications that demand low latency are assigned to the real-time category. VDI and application virtualization solutions, VoIP, Skype for Business and video conferencing applications, and other enterprise applications can be assigned to realtime or interactive categories according to business policy. Lower-priority applications are assigned to the bulk category . In some organizations these three categories are satisfactory, but if more granularity is required custom rules can be created based on factors such as source and destination IP addresses, IP protocol, DSCP tag, and source and destination ports .Each category of application, and even each individual application, can be assigned a minimum share of bandwidth. If the network is congested, each application can continue to function and high priority applications can't be crowded out. And with our SD-WAN, the bandwidth is reserved on the first and last mile, meaning that if the far end is congested, it can back pressure the near end to prevent traffic from being sent to an oversubscribed end point, resulting in more efficient bandwidth utilization .

SD-WAN Basics #3: Combine Network Measurements With Application Policies To Intelligently Route Traffic

Our SD-WAN solution uses several techniques to ensure excellent, reliable performance for business critical applications.The core approach is called "latency-aware path selection." This means performing intelligent load balancing within a network session to use the optimal WAN path or paths. Based on information from the "map" of available network links, a high-priority application is assigned to the lowest latency (best performing) WAN path available at that moment. If the bandwidth requirements of the application exceed the bandwidth available on that path, part of the application traffic is sent through the next-best path, and if necessary through a third or fourth. The paths can be a mix of MPLS and broadband links. This aggregation allows high-priority applications to take advantage of the fastest paths available, without overloading any single path .The path selection process is dynamic. If a particular path begins to slow down or experience excessive jittering or packet loss, high-priority traffic is reassigned to a better performing path on the fly, without interruption to the application. If a higher-priority session starts, that traffic is assigned to he best performing path, and if necessary lo er-priority applications are moved to the next-best path.

Packet Duplication

An additional enhancement technique is "packet duplication." Duplicate copies of each packet can be sent along different, independent paths. The packet that reaches the destination appliance first is used andthe second one is discarded.

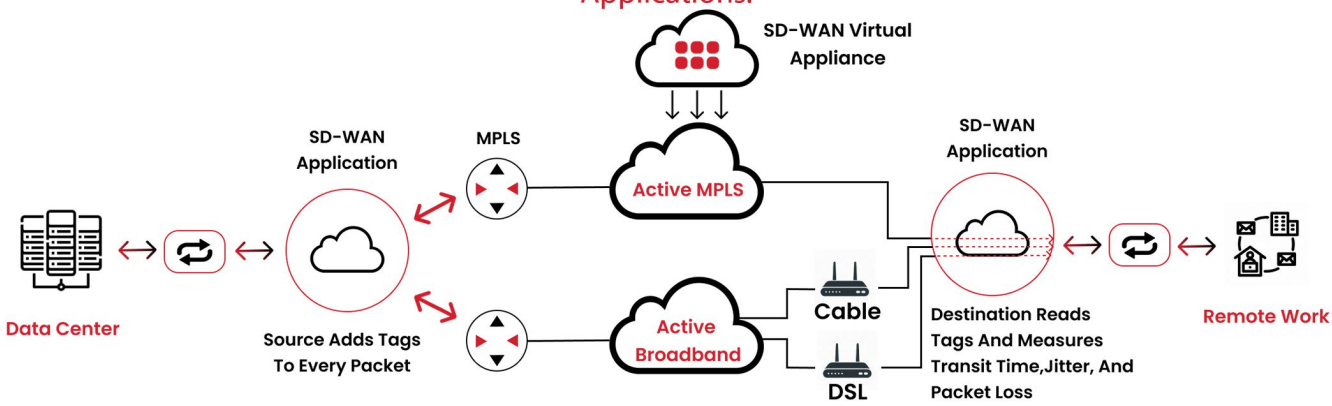


This approach uses extra bandwidth, but it ensures the highest possible perfomance and zero packet loss, making it and zero packet loss,making it appropriate for applications like VoIP, Skype for Business and video conferencing where excellent performance is essential and bandwidth is low.

Traffic Shaping and Dynamic Bandwidth Reservation

Traffic shaping and dynamic bandwidth reservation are additional techniques for managing quality of service for different classes of application traffic .With traffic shaping, it is possible to specify a minimum reserved bandwidth for each of the services, so that no one service ever can crowd out the others on a path. A "share" for each service is also specified. When two or more services are contending for capacity above the reserved minimum, bandwidth is allocated between them based on the relative shares assigned to each. When a service exceeds its bandwidth share, low-priority traffic within that service is queued and transmitted when spare capacity is available .The Virtual Path service (traffic between two SDWAN appliances) provides an even more sophisticated type of traffic shaping that allows the destination appliance to "backpressure" the source appliance. That is, the source appliance not only allocates bandwidth among the service types, it also checks on the load at the destination appliance. If the destination appliance has no available capacity, then the source appliance will hold back on that traffic and use the resulting free bandwidth to send packets somewhere else. This allows more efficient use of overall bandwidth.Traffic shaping and bandwidth reservation ensure that an adequate amount of bandwidth is always available for high-priority applications. Also, because traffic shaping is managed dynamically, our SD-WAN solution makes optimal use of available capacity at all times.These features, along with the other capabilities of our SD-WAN, ensure MPLS-level quality and reliability for high-priority applications on broadband connections, even when the underlying connections are not of high quality. That means that enterprises can expand their WAN bandwidth with inexpensive and flexible broadband connections rather than paying for much more costly MPLS capacity .

A Virtual Appliance Provides Visibility and Control for Traffic to Amazon Web Services (AWS) and SaaS Applications.



Failover and Survivability

Provisions for failover and survivability are important elements of the software-defined WAN. The SD-WAN appliances tag packets with sequence numbers and information about the packets to follow. This allows destination appliances to detect path outages after just two or three missing packets. Information about the outages is immediately shared with all other appliances. Because these applianceshave visibility into all of the WAN links, they can immediately reroute traffic onto the next-best available paths. This approach allows seamless sub-second-failover, undetectable by applications using the new paths. Competing solutions can't match this level of failover performance. Another benefit of this approach is that all applications are not degraded equally. On the contrary, high-priority applications are given the most bandwidth on the remaining paths, so that in most cases users of these applications are not even aware that a network outage ever took place. Finally, when an outage is detected, our SD-WAN appliances will send frequent probes to determine the health of the failed path. When the path is brought back on line, the appliances can resume using it in less than a second.

Packet Reordering and Loss Mitigation

Packet reordering is another element of SDWAN that can improve application performance.When destination appliances receive packets out of sequence, they can reorder them using the sequence number in the packet header.

This offloads the reordering task from applications,resulting in better and more consistent application performance. Packet loss mitigation by the appliances can also boost performance. When the destination appliance determines that packets have been dropped, they contact the source appliance to resend them. This offloads retransmission tasks from applications, and prevents automatic TCP corrections that can cause window sizes to drop rapidly and adversely affect performance.

Locations Without Appliances

Our SD-WAN solution provides optimal results between locations with appliances at both ends. However, it can also provide significant benefits when there is an appliance on only one end.

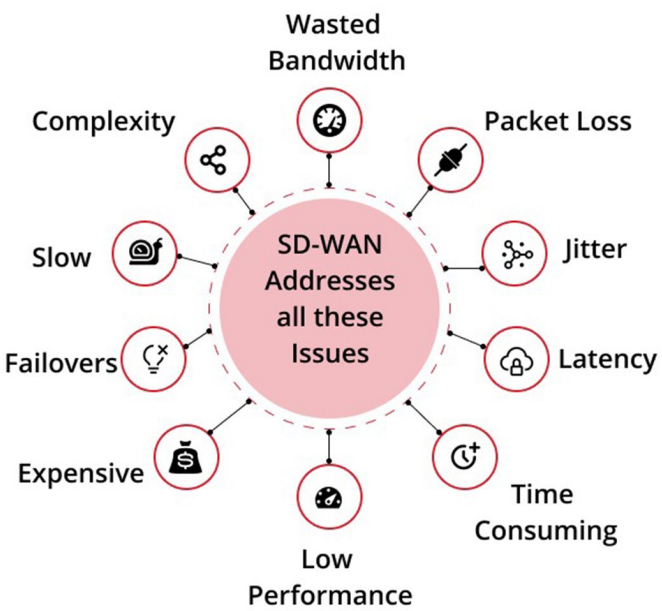
SD-WAN Basics #4: Integrating Public and Private Clouds

Most enterprises are increasing their use of applications running in public and private clouds. Unfortunately, when application traffic enters a cloud-based data center, it effectively leaves the WAN boundary and becomes invisible to the enterprise IT organization . To address this issue, our SD-WAN solution offers a virtual appliance that runs in Amazon Web Services (AWS) regions, or in any data center as a software . This effectively expands the WAN boundary to the edge of the cloud. Our SD-WAN appliances and virtual appliances can aggregate multiple broadband and Direct Connect links, and provide latency-aware path selection, packet duplication and seamless failover for users accessing cloud data and SaaS applications.

SD-WAN Basics #5: Consolidate Branch Network Functions Into a Single Appliance

Our SD-WAN offers a complete all-in-one solution that includes application-aware virtualized WAN connectivity, dynamic routing, WAN optimization, secure data segmentation, and secure Internet breakout. This limits the number of separate appliances that need to be deployed in a branch, and provides a single centralized management system for configuration and reporting .

This approach drives down the cost of the branch network, not only by limiting the number of appliances that have to be individually purchased, but by lowering the technical support costs per branch. A single configuration system means that IT staff doesn't have to learn multiple technologies and coordinate changes across multiple systems. This means that the time and cost of configuration is less and lowers the risk of errors that can result in network downtime. Our SD-WAN solution supports multiple deployment modes allowing customers to overlay the SD-WAN technology on their existing network, aggressively rearchitect their WAN to consolidate network services, including routing, into a single appliance, or selectively deploy SD-WAN in the mode best suited to each location .



SD-WAN Basics #6: Centralized Policies, Simplified Management and Visibility

WANs with multiple network types can be hard to manage. Our SD-WAN solution simplifies management and analysis. Our web interface makes configuring SD-WAN appliances and policies intuitive, especially because the WAN can be configured in its entirety, rather than as a series of individual device.

The interface includes a dashboard with charts, maps and diagrams that display key facts and events showing the health and performance of WAN paths across the network. A unique replay feature shows traffic flows over time and highlights changes resulting from changes in network conditions and application demand .

Our SD-WAN solution is the only SD-WAN offering that provides this level of insight into application traffic over wide area networks .

SD-WAN Results: Noticeable Improvements to Application Reliability, Performance and The Business Bottom Line

The "What Can go Wrong" section above discussed seven issues that arise with typical WAN connections today: wasted bandwidth, slow and disruptive failovers, degraded performance of high-priority applications after a failover, the high cost of adding capacity, packet loss and jitter on MPLS networks, and complex and time- consuming administration. Our SD-WAN addresses all of these issues.

No Wasted Bandwidth

Intelligent path selection across all connection-types ensures that all bandwidth is available at all times. It is no longer necessary to reserve broadband connections primarily for backup. Further, the highest-priority application traffic is assigned to the paths with the best performance and lowest packet loss. Assignments are made dynamically, based on granular classification of each application and real-time information about the performance and health of every path in the WAN.

This dynamic path selection is performed automatically, without requiring network administrators to analyze or monitor network links or assign applications to paths.

Sub-Second Failover and Failback

Our SD-WAN appliances can detect path outages after just two or three missing packets, allowing seamless sub-second failover of application traffic to the next-best WAN path. Employees are never forced to restart sessions, redial calls, or log in to applications again. The appliances also detect immediately when connections come back online, and seamlessly return traffic to the restored paths.

High-Priority Applications Perform Well After Failover

When a connection goes down, traffic shaping and latency-aware path selection ensure that high-priority applications are given adequate-bandwidth on the best-performing remaining-paths. Packets for lower-priority "bulk" applications are queued if necessary and sent when bandwidth is available. In most cases outages are undetectable by employees, even with latency-sensitive applications like VoIP.

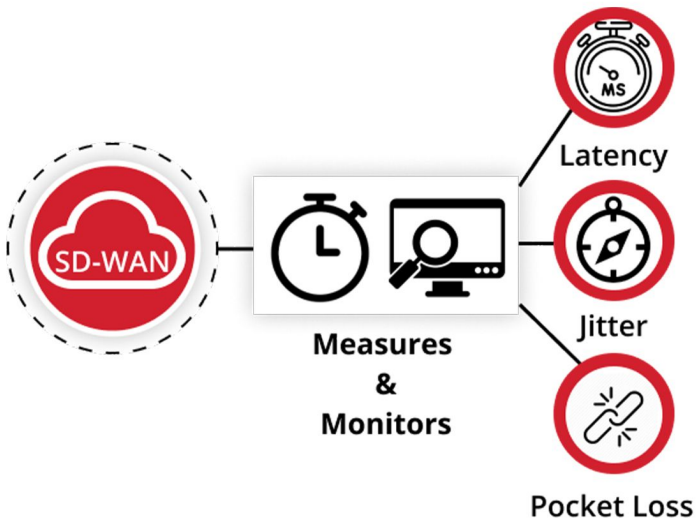
Dramatically Lower Costs For Expanding Capacity

Our SD-WAN solution allows broadband connections to deliver high-priority application traffic with the same reliability and quality of service as far more expensive MPLS networks. That means enterprises can expand their WAN capacity using low-cost, flexible broadband connections, and have those connections work seamlessly with an existing MPLS network. In fact, some enterprises may be able to dispense with MPLS entirely and build high-quality WANs using broadband links alone.

Better Quality for All Application Types

Our SDWAN appliances continuously measure and monitor the latency, jitter and packet loss of every WAN connection.

They dynamically make routing decisions to use the best quality paths as much as possible. Lower quality paths are used only as much as necessary, and then for lower priority applications. Packet reordering and packet loss mitigation features reduce jitter and packet loss, improving the quality of MPLS as well as broadband connections .



Consolidated Branch Networking

Our SD-WAN integrated edge solution combines software-defined WAN capabilities with WAN Optimization, routing and security in a single appliance. This allows enterprises to choose which network functions it needs for each branch without worrying about purchasing and managing separate appliances for each function .

Simplified, End-to-End Management and Monitoring

Our SD-WAN solution makes it simple to manage and monitor performance and quality on WANs that combine multiple MPLS and broadband connections. Administrators can configure WANs in their entirety, rather than as series of individual devices. They can also push WAN visibility and management into the cloud, with virtual appliances running in Amazon Web Services (AWS) regions or any Data Center.