Cisco Catalyst 8000 Edge Platforms Family

SD-WAN Performance Validation

May 2023

DR230430E

Contents

1.0 Executive Summary

The demand for working at home has skyrocketed significantly in the last few years, and the need for technology and hardware to support this change has followed suit. Applications are moving into the cloud at a faster rate leading to a search for a new approach in network architecture that offers more flexibility without compromise.

Miercom was engaged by Cisco Systems to independently validate the functionality and performance of its SD-WAN solution, enabled by the Catalyst 8000 Edge Platforms Family. By subjecting the Cisco solution to a real-world deployment, Miercom engineers validated throughput, scalability, and management. Testing assessed the impact of various configuration settings and deployment options on the throughput performance of the SD-WAN solution. We found this solution offered significant benefits for the modern enterprise branch and aggregation head-ends.

Key Findings for the Cisco Catalyst 8000 Edge Platform Family

The Catalyst 8000 family offers best-in-class hardware with rich software features for high-performance emerging SD-WAN use cases.

- **Catalyst 8000 Series Architectural Innovation.**
  - **QFP 3.0 for Catalyst 8500 Series.** The use of Quantum Flow Processor (QFP) 3.0 Application-Specific Integrated Circuit (ASIC) enhances hardware for boosted performance (with embedded service applications, high-speed forwarding, integrated Layer 2 IPSec crypto functionality) to handle oversubscription and flow control
  - **Dynamic Core Allocation.** This capability allows for flexible use of CPU cores based on service-focused or data plane-focused deployment needs
- **Performance and Scale Improvements.**
  - **High Performance.** Looking at different profiles that emulate real-world scenarios (features enabled and traffic sizes), we found the Catalyst Edge Series could reach performance as high as 383.9 Gbps
  - **Scalable Handling.** To determine scalability, we observed up to 8,000 IPSec Tunnels, 330,000 OMP Routes, 1 million DPI Flows, and 1 million cFlows - proving powerful scaling capabilities for SD-WAN aggregation deployments, branch and mesh SD-WAN architectures, and small to mid-sized branches
- **Licensing Simplicity.** Cisco offers a consistent licensing model across its entire Intent Based Networking portfolio for Campus, WAN, and Cloud. This zero-day setup provides a rich set of tiered features - Essentials, Advantage, and Premier to simplify performance while addressing bandwidth requirements. These licenses are portable between different platforms, reducing Total Cost of Ownership (TCO)

Cisco SD-WAN brings a centralized, software-defined approach to network management which intelligently automates, simplifies and controls to yield high performance. Cisco Catalyst 8000 Edge Platforms improve scale, throughput and simplify licensing. We proudly award Catalyst 8000 Platform the ***Miercom Performance Verified*** certification.

Robert Smithers

CEO, Miercom

2.0 Testing Summary

Miercom observed performance testing using hands-on network testing tools. Business environments were simulated and challenged with real-world traffic scenarios to provide an accurate assessment of product performance.

2.1 SD-WAN Throughput Performance

Profile 1

Platform	1400 bytes (Gbps)	512 bytes (Gbps)
C8500-20X6C	383.9	161.5
C8500-12X4QC	65.1	41.2
C8500L-8S4X	18.8	14.2
C8300-1N1S-4T2X	16.6	9.27
C8300-1N1S-6T	2.00	1.83
C8200L-1N-4T	0.5	0.46
C8200-UCPE-1N8	1.9	0.83

Profile 2

Platform	1400 bytes (Gbps)	512 bytes (Gbps)
C8500-20X6C	208.4	76.1
C8500-12X4QC	48.8	18.3
C8500L-8S4X	18.8	8.70
C8300-1N1S-4T2X	13.9	8.20
C8300-1N1S-6T	2.00	1.83
C8200L-1N-4T	0.49	0.45
C8200-UCPE-1N8	1.02	0.38

Profile 3 EMIX

Platform	Throughput (Mbps)
C8300-1N1S-4T2X	1472
C8300-1N1S-6T	1028

2.2 Multi-dimensional Scale Testing

Platform (DUT)	IPSec Tunnels	OMP Routes	DPI Flows	cFlows
C8500-12X4QC	8,000	330,000	1,000,000	1,000,000
C8500L-8S4X	8,000	300,000	512,000	512,000
C8300-1N1S-4T2X	6,000	100,000	100,000	100,000
C8300-1N1S-6T	6,000	100,000	100,000	100,000
C8200L-1N-4T	1,500	70,000	100,000	100,000
C8200-UCPE-1N8	500	50,000	50,000	50,000

3.0 Product Tested

3.1 Catalyst 8500 Series Edge Platforms

The Catalyst 8500 Series hosts the innovative third-generation Cisco Quantum Flow Processor (QFP) 3.0 Application-Specific Integrated Circuit (ASIC). The platforms are equipped with a built-in route processor, an embedded services processor, and interface connectivity using Ethernet ports.

The Cisco Catalyst 8500 Series Edge Platforms are fixed form factor, 1 and 3 rack-unit aggregation platforms. Three models are available:

- C8500-20X6C
- C8500-12X4QC
- C8500-12X

QFP 3.0 enhances hardware-based forwarding, bringing it to a whole new level. Along with embedded services applications and high-speed forwarding, QFP 3.0 also hosts integrated Layer 2 subsystem and IPsec crypto functionality within the same data plane ASIC. The Catalyst 8500 series edge platforms are designed to allow ingress oversubscription and event driven flow control at various stages of packet processing.

C8500-20X6C Platform

C8500-12X4QC Platform

C8500-12X Platform

The C8500-20X6C platform is a highly flexible and scalable SD-WAN headend that simplifies network designs eliminating the complexity of horizontal scale-out with 100Gbps aggregate IMIX performance. The platform is built with the sufficient buffering ability to handle I/O over-subscription, ensure traffic prioritization, and offers more x86 cores for edge-compute service planes to host KVM and LXC applications including ThousandEyes monitoring. The C8500-20X6C platform offers a higher density of 100G and 40G interfaces than any other platform in the Catalyst 8500 Series. All the built-in ports offer WAN MACsec line-rate encryption. A maximum forwarding rate of 536 Gbps is possible by utilizing four of the QFP 3.0 ASICs in the dataplane.

With C8500-12X4QC platform, a maximum of 240 Gbps of traffic aggregation is possible. All the built-in ports support synchronous Ethernet and WAN MACsec capabilities. WAN MACsec offers line-rate encryption capabilities.

The C8500-12X platform, on the other hand, allows a maximum of 120 Gbps of traffic aggregation.

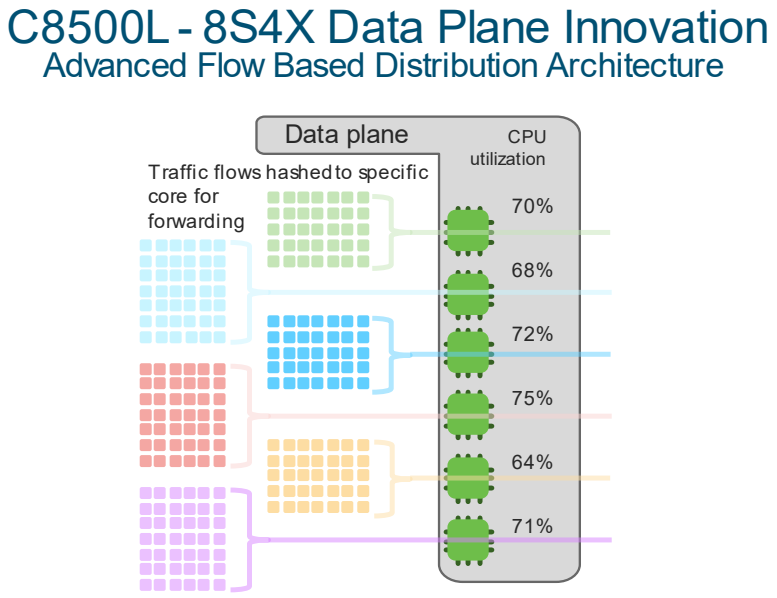
The Catalyst 8500 Series has a powerful QFP 3.0 driven data plane, a highly scalable control plane, built-in interface flexibility with options for 100 GE, 40 GE, 10 GE, and 1 GE and more importantly, hardware-accelerated services.

The Catalyst 8500L platform is purpose built to serve lower end WAN aggregation capacities. The platform is built on x86 System-on-chip (SoC) multicore CPU architecture. There are several software and hardware aspects that differentiate the Catalyst 8500L from the other x86 based platforms.

The Cisco Catalyst 8500 Series Edge Platform is a fixed form factor, 1 rack-unit aggregation platform. One model is currently available:

- C8500L-8S4X

C8500L-8S4X Platform



C8500L-8S4X Platform Data Plane Innovation

A key data path innovation on C8500-8S4X platform architecture is the advanced flow based forwarding algorithm and the x86 SoC allows the cores to be distributed dynamically in 'data-plane-heavy' or 'service-plane-heavy' mode. In 'data-plane-heavy' mode, most cores are allocated to data forwarding operations, enabling the platform to deliver maximum possible performance. In 'service-plane-heavy' mode some cores are repurposed to orchestrate container hosted services; this mode allows hosting SD-WAN embedded security services.

The Catalyst 8500 Series offers best-in-class hardware with rich software features for high-performance SD-WAN, traditional routing, and emerging colocation use cases.

3.2 Catalyst 8300 / 8200 Series Edge Platforms

The Catalyst 8300/8200 Series Edge Platforms are built on an x86 SoC multicore CPU architecture designed for interface flexibility and modularity.

C8300-2N2S-4T2X Platform

C8300-1N1S-4T2X Platform

C8300-2N2S-6T Platform

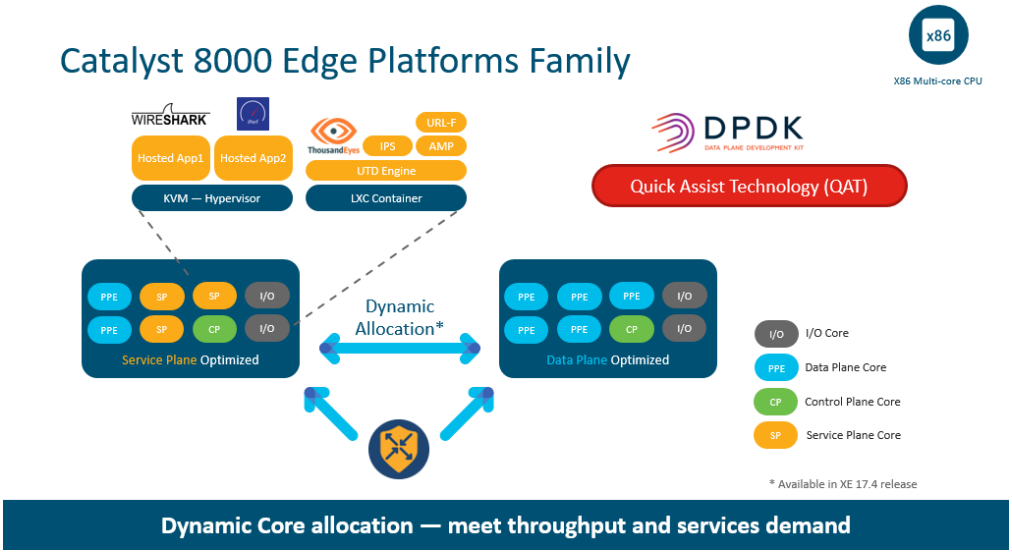
C8300-1N1S-6T Platform

Cisco Catalyst 8300 Series Edge Platforms comes in modular form factor 1 and 2 rack units for medium to large scale enterprise branch deployments. There are four models available:

- C8300-2N2S-4T2X
- C8300-1N1S-4T2X
- C8300-2N2S-6T
- C8300-1N1S-6T

The C8300 Series Edge Platforms are built for interface flexibility and modularity with 6 built-in WAN ports. Depending on the above platforms listed, you can utilize one or two Network Interface Module (NIM) slots, one or two Service Module (SM) slots and one dedicated Pluggable Interface Module (PIM) slot. NIM and SM modules can offer Data, Voice, Compute and Storage capabilities. PIM modules offer high-speed Cellular WAN connectivity. With advanced modularity and capability, the Cisco Catalyst 8300 Series Edge Platforms are ready to adapt to emerging technologies.

The platforms support dynamic core allocation capability — one of the key data path innovations in SoC architecture platforms. This capability enables flexibility for productively using the CPU cores based on the needs of service-focused or data plane-focused deployment models.



Catalyst 8300/8200 Series Edge Platforms Data Plane Innovation

In addition, the Data Plane Development Kit (DPDK) libraries and Quick Assist Technology (QAT) engine boosts the data plane performance for Cisco Express Forwarding (CEF), crypto IPsec traffic, and other services.

Cisco Catalyst 8200 Series Edge Platforms comes in modular form factor fixed 1 rack units for small to medium scale enterprise branch deployments. The platforms are built for interface flexibility and modularity with 4 built-in WAN ports, one Network Interface Module (NIM) slot, and one dedicated Pluggable Interface Module (PIM) slot. There are two models available:

- C8200-1N-4T
- C8200L-1N-4T

C8200-1N-4T Platform

C8200-1N-4T Platform

Like C8300 platforms, the C8200 platforms offer data path innovations such as dynamic core allocation, DPDK and QAT to boost the data plane performance.

3.3 Catalyst 8200 Series Edge uCPE

Cisco Catalyst 8200 Series Edge uCPE (Universal Customer Premise Equipment) is foundational for branch virtualization, combining routing, switching, and application hosting into a compact, one rack-unit (1RU) form factor for small and lean virtualized branch. Cisco provides an end-to-end virtualization solution with Cisco's own hypervisor Network Function Virtualization Infrastructure Software (NFVIS), Catalyst 8000V Routing Virtual Network Functions (VNFs), and flexible orchestration choices. The model number is:

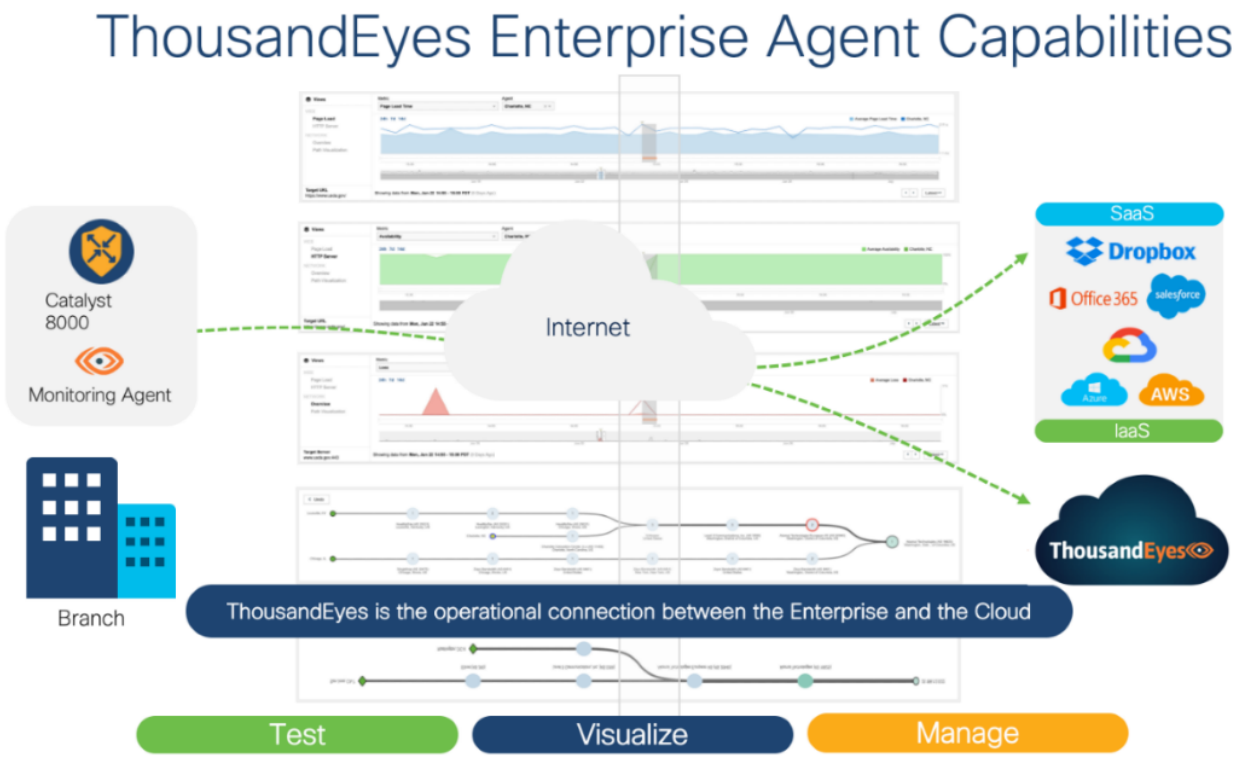
- C8200-UCPE-1N8

C8200-UCPE-1N8 Platform

With eight x86 CPU cores, the platform enables branches to run multiple VNFs. VNFs can be provisioned with desired compute, memory, and storage footprint. Cisco's virtual router, Catalyst 8000V, can be configured with 2 or 4 CPU cores and it benefits from the Intel Quick Assist Technology (QAT) for IPsec acceleration. The modular platform includes one Network Interface Module (NIM) slot for additional WAN and LAN modules as well as a Pluggable Interface Module (PIM) slot for cellular WAN connectivity. Cisco vManage offers a single pane of glass for lifecycle management of uCPE hardware and software components.

3.4 ThousandEyes Support on Catalyst 8000 Family

The Cisco ThousandEyes Network Intelligence platform allows users to run synthetic network and application tests from over 350 global vantage points as well as from internal networks to monitor network and application performance. It enables end-to-end visibility for paths across networks and services. Indirectly the real-time monitoring enables network performance analysis across internal, external and internet network endpoints.



ThousandEyes Enterprise Agent

Cisco ThousandEyes Enterprise Agent application, a different component of the Thousand Eyes Network Intelligence Platform, can be hosted as a container service on both Cisco Catalyst 8300 and 8200 Series Edge Platforms beginning with IOS XE 17.6.1. Cisco Catalyst 8500 Series Edge Platforms and the Catalyst C8500L-8S4X support hosting the ThousandEyes Enterprise Agent application beginning with IOS XE 17.8.1. The virtualized container is managed using IOx. IOx is Cisco's Application Hosting Infrastructure for Cisco IOS XE devices. It enables hosting of applications and services developed by Cisco, partners, and third-party developers in network edge devices, seamlessly across diverse and disparate hardware platforms.

3.5 Catalyst 8000 Platforms Licensing Simplicity

Cisco Catalyst 8000 Series Edge Platforms utilizes a simplified Cisco DNA licensing model that is common and portable to other models in the Catalyst 8000 family. Choose from a total of three feature packages (Essentials, Advantage, and Premier) and six bandwidth tiers across the Catalyst 8000 family.

Listed below are key benefits of Cisco DNA licensing for the Catalyst 8000 Series Edge Platforms:

- Simplified licensing and consistent terminology across Cisco's Catalyst products
- Consistent feature packaging within the Catalyst 8000 family (e.g. Cisco DNA Advantage provides the same feature entitlement between C8300, C8500, and other models)
- Fewer but wider bandwidth tiers in the Catalyst 8000 family simplifies license management
- License portability between different models in the Catalyst 8000 family, thereby reducing Total Cost of Ownership (TCO)
- The same Cisco DNA licenses enable the Catalyst 8000 Edge Platforms to be used for Routing or SD-WAN

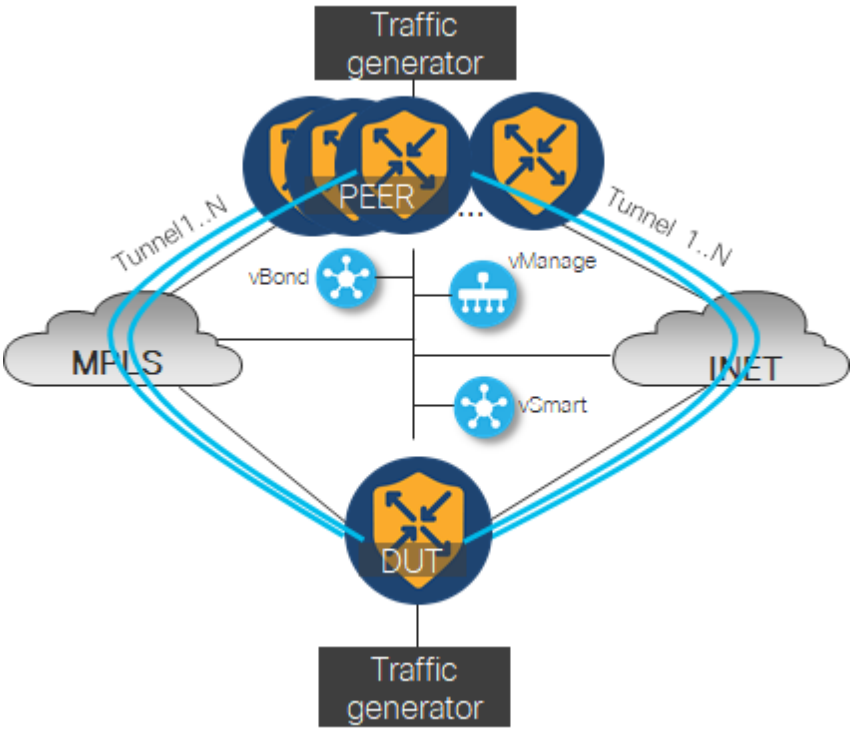
4.0 How We Did It

Miercom participated in hands-on testing with a real-world network environment simulated by industry leading traffic generation tools for a realistic assessment of performance. Using a realistic network environment, we tested C8500-20X6C, C8500-12X4QC, C8500L-8S4X, C8300-1N1S-4T2X, C8300-1N1S-6T, C8200-1N-4T, C8200-UCPE-1N8 platforms.

Testing of the Cisco Catalyst 8000 Series Edge Platforms focused on:

- SD-WAN Throughput Performance
- SD-WAN Multi-dimensional Scale Performance

4.1 Test Topology



Ixia IxNetwork generated 100 servers and 1,000 clients to simulate 1,000 one-to-many flows of bidirectional traffic with randomized IP addresses. The test duration was 120 seconds, measuring aggregate throughput and No Drop Rate (NDR), zero packet drop for Catalyst 8500, Catalyst 8300, and Catalyst 8200 platforms. For the Catalyst 8000V VNF instance used in Catalyst 8200 uCPE, 0.01% drop rate was allowed. Ixia's built-in RFC-2544 test suite was used for binary search based NDR look up to obtain the result.

We used two different IPv4 Unicast packet profiles, measured in bytes(B) for "Dataplane optimized profiles" and a EMIX stateful traffic profile for "Service Optimized" feature sets. For IPv4 unicast profiles, we used the following payload sizes:

- Mid-size packets: 512 Bytes (B)
- Large packets: 1400 Byes (B)

Packet sizes are defined as Ethernet frame size: Ethernet Header (DMAC/SMAC/EtherType) + Ethernet FCS + IP Header.

Multi-dimensional scale test for SD-WAN solution were executed using Spirent Test Center traffic generator for simulating flows and session scale. Scale test topology used for establishing multiple IPsec tunnels. To simulate SD-WAN overlay tunnel scale, virtual SD-WAN edge instances were used as remote peers in scaled fashion.

The number of flow entries were observed and recorded. These results were intended to verify design specification as advertised by Cisco scalability claims.

SD-WAN Throughput Performance

This test used three throughput profiles of different feature combinations of Internet Protocol Security (IPsec), Quality of Service (QoS), Deep packet Inspection (DPI), Flexible NetFlow (FNF), Network Address Translation (NAT), Firewall, Intrusion Prevention Service (IPS), URL Filtering (URLF), Advanced Malware Protection (AMP) and Threat Grid (TG).

The following throughput profiles were generated by the Ixia BreakingPoint and Spirent test tools. Profile 1 and Profile 2 utilized packet sizes 512 bytes and 1400 bytes.

Profile	Traffic Type
Profile 1	IPSec (512B, 1400B) – Dataplane Optimized Mode
Profile 2	IPSec + QoS + DPI + FNF (512B, 1400B) – Dataplane Optimized Mode
Profile 3	IPsec + QoS + DPI + FNF + DIA-NAT + Stateful Firewall App Aware + IPS + URLF + AMP + TG (EMIX Stateful traffic using Ixia BreakingPoint Firestorm Traffic Generator) – Service Optimized Mode

Device Under Test (DUT)	Platform	Profiles
DUT 1	C8500-20X6C	1 and 2
DUT 2	C8500-12X4QC	1 and 2
DUT 3	C8500L-8S4X	1 and 2
DUT 4	C8300-1N1S-4T2X	1, 2 and 3
DUT 5	C8300-1N1S-6T	1, 2 and 3
DUT 6	C8200L-1N-4T	1 and 2
DUT 7	C8200-UCPE-1N8	1 and 2

SD-WAN Multi-dimensional Scale Performance

The SD-WAN Multi-dimensional Scale performance tests were designed to estimate multi-feature scale capabilities for Catalyst 8000 Series Edge Platforms. The following features were enabled for this series of tests:

- SD-WAN Tunnels
- DPI (Deep Packet Inspection)
- cFlow
- OMP Routes

4.2 Device/Versions

The following devices were used for both throughput and scale test environments for SD-WAN.

Device Under Test (DUT)	
Hardware/Software	*Version*
C8000V on C8200-UCPE-1N8	IOS XE 17.6.1 and NFVIS 4.6.1
C8500-20X6C	IOS XE 17.10.1a
C8500-12X4QC	IOS XE 17.6.1
C8500L–8S4X	IOS XE 17.7.1
C8300–1N1S–6T	IOS XE 17.6.1
C8300–1N1S-4T2X	IOS XE 17.7.1
C8200L–1N–4T	IOS XE 17.6.1
SD-WAN Controller	20.6.1

The following tools were used to carry out the performance tests.

Test Tools		
Hardware/Software	*Version*	*Description*
Ixia Breaking Point	8.50	BreakingPoint optimizes security devices by simulating live security attacks and invasions. By sending a mixture of application traffic and malicious traffic, this tool determines IPS and AV capabilities for detecting threats while remaining resilient. The “Critical Strike Pack” uses variants, or randomized path combinations, to exploit. Dynamic, “smart” exploits attack hosts and applications and are customizable for specific scenarios (ATI-Strike Pack 2019, Evergreen 2019, Malware 2019, Daily Malware current as of December 2020).
Ixia IxNetwork	9.1 8.0	A high-speed test tool to generate traffic flows and routes emulation to validate the scalability of the platform in this test.
Spirent Test Center	4.54	A high-speed test tool to generate traffic flows and routes emulation to validate the scalability of the platform in this test.

5.0 SD-WAN Throughput Performance

Today's networks are experiencing ever increasing throughput demands with services applied at WAN edge routers. In SD-WAN deployments, the demand for higher throughput is witnessed at every place in the network – branch, edge, aggregation and colocation.

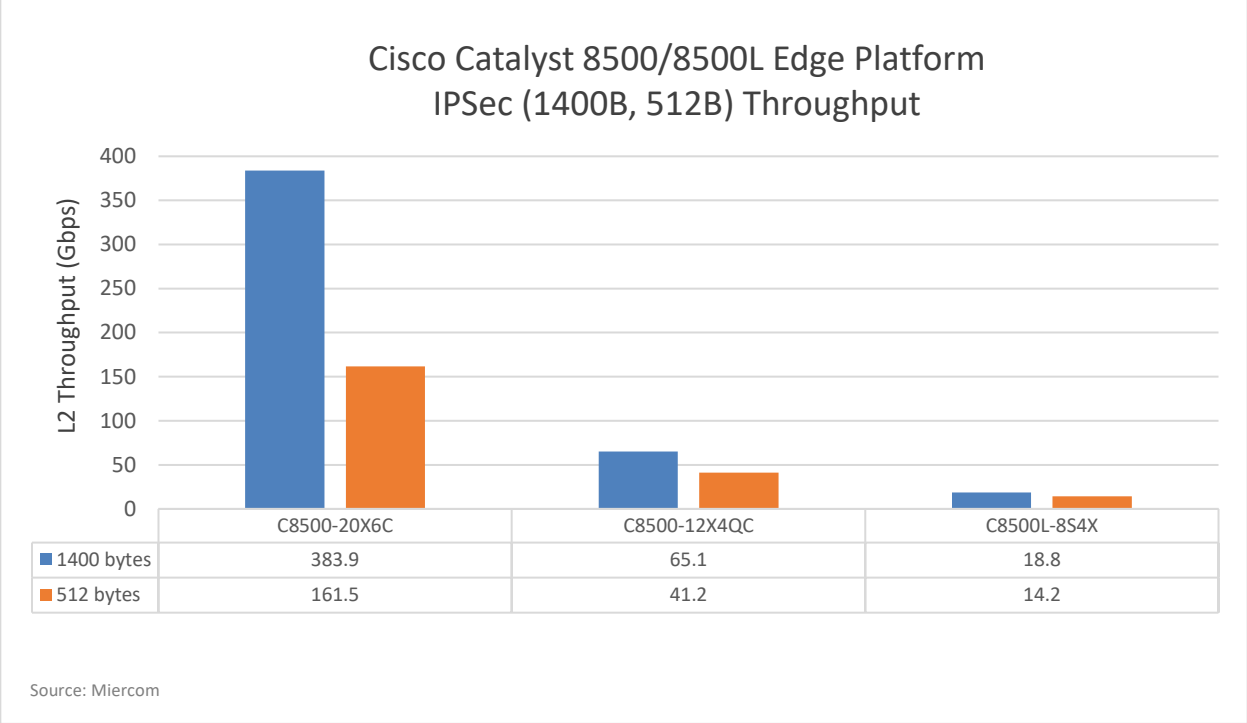
Our testing intended to validate throughput performance incurred while protected by Cisco Catalyst 8000 Series Edge Platforms using SD-WAN rich features.

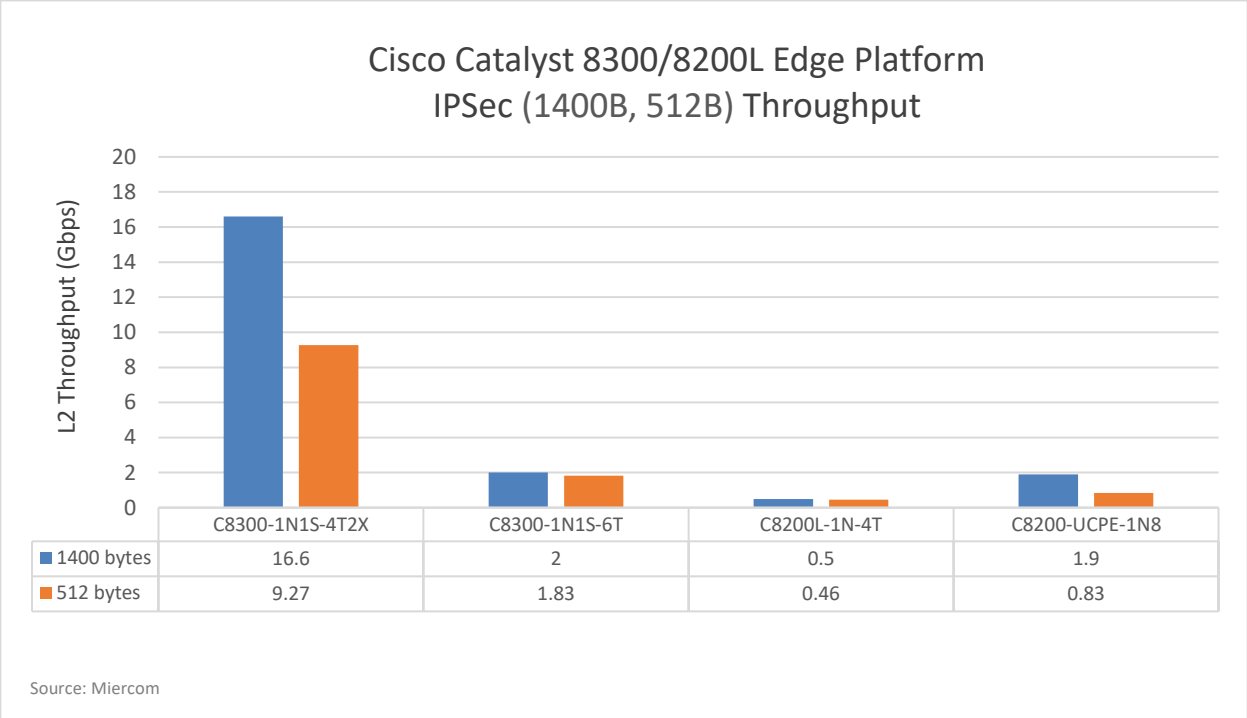
The following are key considerations for our observed performance results:

- **Clear text traffic throughput values:** The published results are based on clear text traffic measurements from the traffic generator; it does not include encrypted header bits processed by the DUT
- **No-drop-rate readings:** Final readings were captured with zero percent traffic drop guidance in the DUT
- **RFC-2544 test suite:** RFC-2544 test suite was used to establish the final reading for result with binary search algorithm

5.1 Profile 1

Profile 1: IPSec (1400B, 512B) – Dataplane Optimized Mode





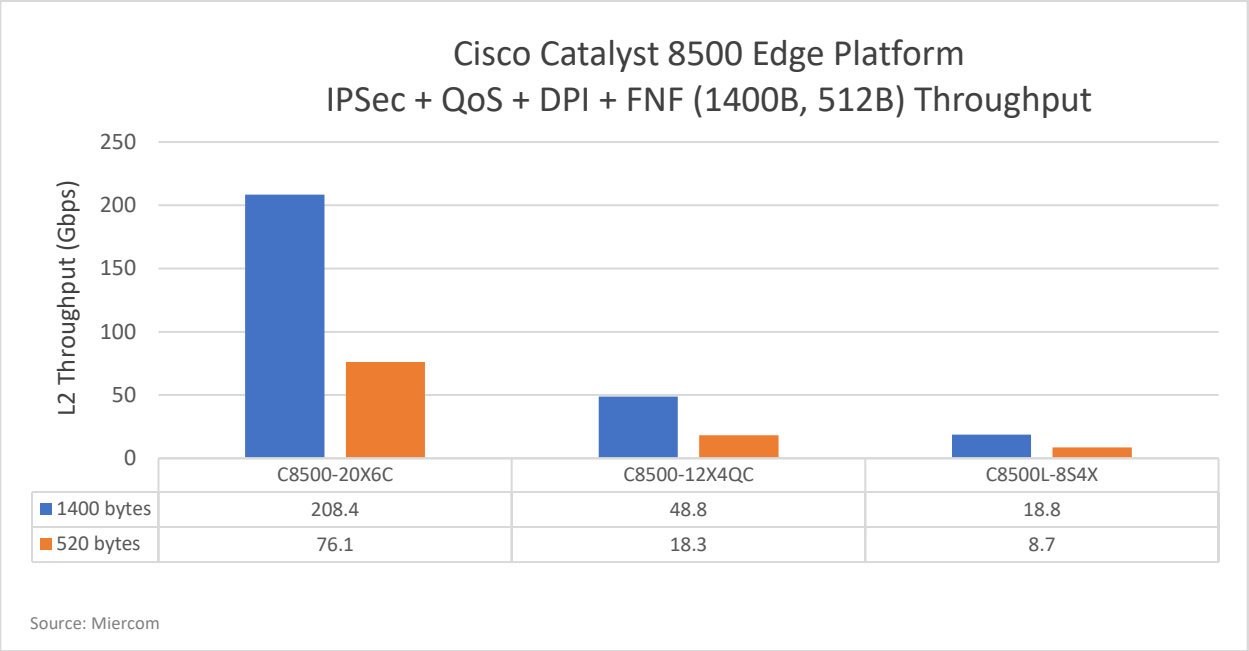
The Cisco Catalyst 8500, 8300 and 8200 Edge Platform Layer 2 throughput performance, utilizing different frame size, demonstrates excellent performance using a traffic profile consisting of IPSec (512B, 1400B) – Dataplane Optimized Mode (Profile 1). The Catalyst 8500 series saw the highest performance – up to 383 Gbps. Note all performance throughput throughout the line meets and exceeds greater than published data expectations.

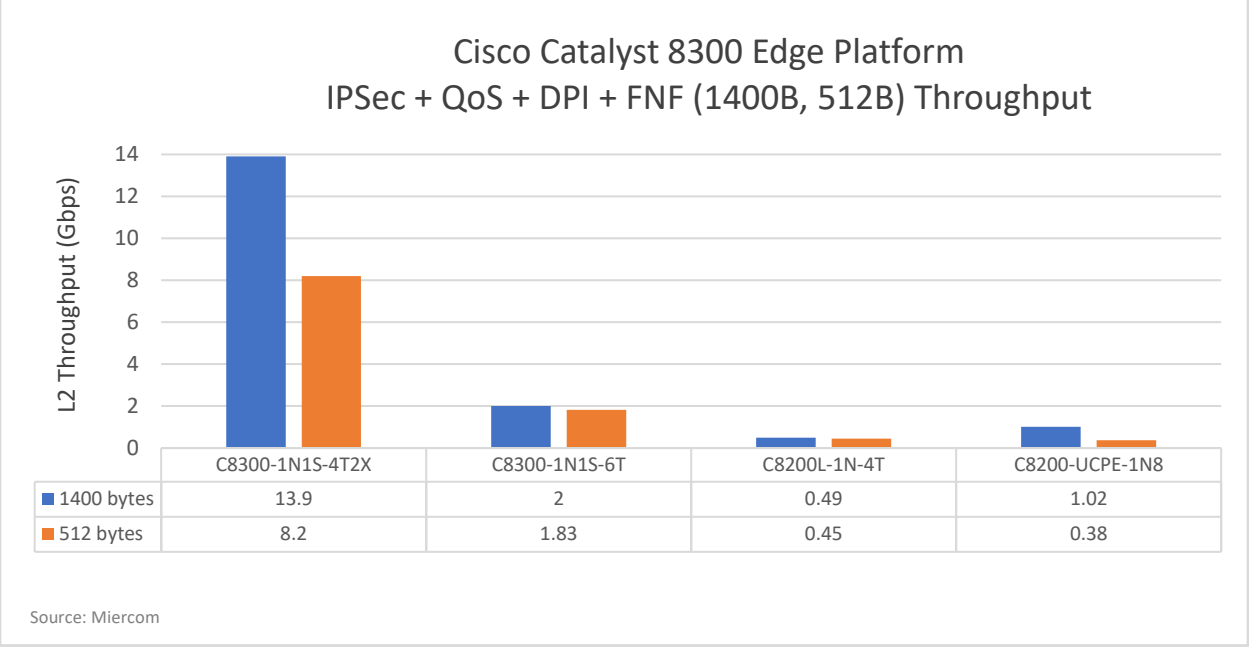
Profile 1 Test Result Summary

- For SD-WAN IPsec, the four QFP 3.0 ASICs with their total of 64 crypto engines deliver the highest throughput performance with the C8500-20X6C platform
- For the low end of WAN aggregation use-cases, C8500L-8S4X platform provides solid crypto throughput with an advanced flow-based distribution data plane and x86 QAT capabilities
- For C8300, C8200 and C8200 uCPE platforms, x86 QAT enablement is resulting in best-in-class SD-WAN IPsec performance for large, mid, and small branch use-cases

5.2 Profile 2

Profile 2: IPSec + QoS + DPI + FNF (1400B, 512B) – Dataplane Optimized Mode





The Cisco Catalyst 8500 and 8300 Edge Platform Layer 2 throughput performance, utilizing different frame size, demonstrates excellent performance using a traffic profile consisting of IPSec + QoS + DPI _+ FNF (1400B, 512B) – Dataplane Optimized Mode (Profile 2). The Catalyst 8500 series saw the highest performance – up to 208 Gbps.

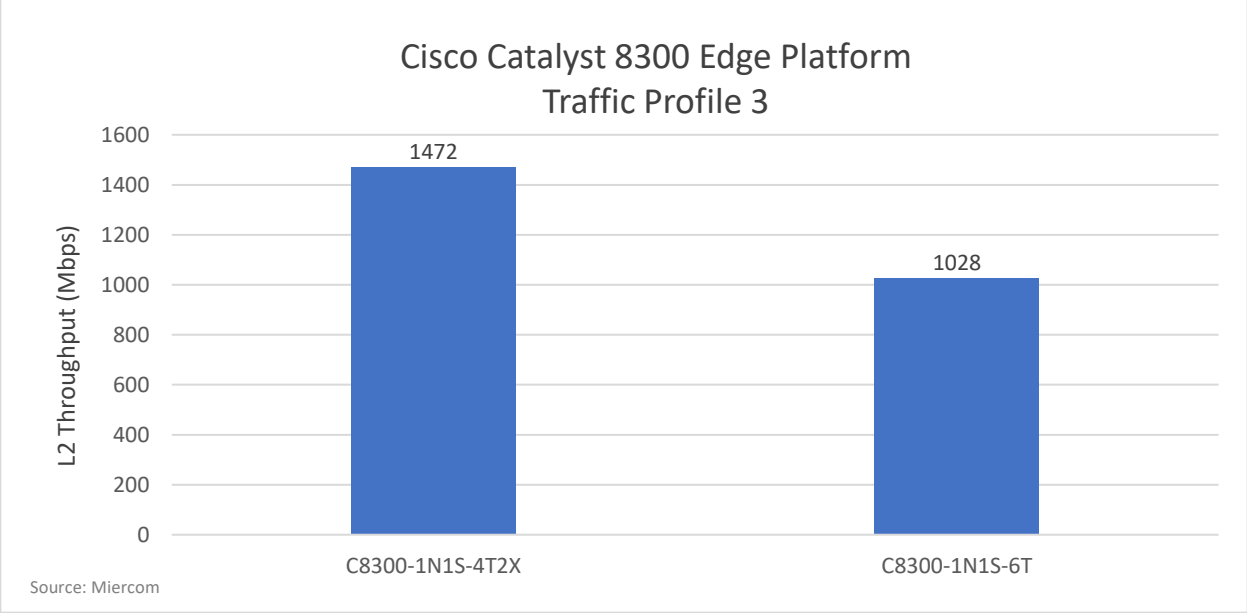
Note all performance throughput throughout the line meets and exceeds greater than published data expectations

Profile 2 Test Result Summary

- This profile enables QoS, DPI and FNF services along with SD-WAN IPsec feature for all DUT configurations.
- C8500-20X6C platform achieves top end performance with unique ability of QFP 3.0 hardware assisted services and multi-threaded parallel processing.
- C8500L-8S4X platform implements per flow core distribution in the data plane, resulting in optimized forwarding with improved services and solid throughput performance.
- Benefits of DPDK enablement in data plane for C8300, C8200 and C8200 uCPE platforms are seen with better services throughput performance.

5.3 Profile 3

Profile 3: IPSec + QoS + DPI + FNF + DIA-NAT + Stateful Firewall App Aware + IPS + URLF + AMP + TG



The Catalyst 8300 models had up to 1,472 Mbps of throughput with the generated traffic mix.

Profile 3 Test Result Summary

- Embedded security capabilities were tested with EMIX traffic simulating a real-world traffic scenario.
- Both C8300-1N1S-4T2X and C8300-1N1S-6T platforms deliver optimal performance for complex security services for SD-WAN branch use cases.

6.0 Multi-dimensional Scale Testing

A good network design should accommodate both present and future demands for services and scale. Since SD-WAN solutions are expected to be flexible in terms of multi-dimensional scale, the following tests are conducted with multiple features to scale up together for real-world deployment scenarios.

Platform (DUT)	IPSec Tunnels	OMP Routes	DPI Flows	cFlows
C8500-12X4QC	8,000	330,000	1,000,000	1,000,000
C8500L-8S4X	8,000	300,000	512,000	512,000
C8300-1N1S-4T2X	6,000	100,000	100,000	100,000
C8300-1N1S-6T	6,000	100,000	100,000	100,000
C8200L-1N-4T	1,500	70,000	100,000	100,000
C8200-UCPE-1N8	500	50,000	50,000	50,000

Multi-dimensional Scale Testing Summary

- Multi-dimensional scale for Catalyst 8500/8500L platforms is well equipped for handling SD-WAN aggregation deployments
- Catalyst 8300 multi-dimensional scale allows them to be a powerful branch even for Mesh SD-WAN architectures
- With Catalyst 8200 and 8200 uCPE platforms, small and mid-size branch scenarios can be effectively handled

Additional References

Please refer the following Miercom SD-WAN reports for additional insights on Cisco SD-WAN architecture and use-cases. Cisco vManage and DNA-C simplifies network management and orchestration for both SD-WAN and traditional deployments.

Cisco SD-WAN with Secure Access Service Edge (SASE) Competitive Independent Solution Assessment

https://miercom.com/cisco-sdwan-with-secure-access-service-edge-competitive-independent-solution-assessment/

Cisco Catalyst 8000V Edge Router Performance Assessment – Miercom Performance Verified

https://miercom.com/cisco-catalyst-8000v-edge-router-performance-assessment-miercom-performance-verified/

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