Miercom

Lab Testing Summary Report

January 2007
Report 070117

Product Category:
Data Center Switch

Vendors Tested:
Cisco Systems
F5 Networks

Product Tested:
Cisco 6500 Application Control Engine Module v A.1.3

F5 8400 BIG-IP v9.2.3

CISCO

Miercom PERFORMANCE VERIFIED

Key findings and conclusions:

- **The Cisco Catalyst 6500 Application Control Engine (ACE) module demonstrated superior speed, throughput and scalability compared to the F5 BIG-IP 8400 switch in comprehensive performance tests**
- **The Cisco ACE provided linear scalability for throughput and connections with multiple modules in a single Catalyst 6500 switch**
- **The Cisco ACE provides improved data center efficiency through lower power consumption and heat output**
- **The Cisco ACE eases and accelerates provisioning and management with unique features including, Hierarchy Domain, RBAC, Virtualization, and Configuration Rollback**

Cisco Systems engaged Miercom to independently verify the performance and various unique features of the new Application Control Engine (ACE) hardware module running software release A.1.3 against F5 Networks BIG-IP 8400 running software v9.2.3. Designed for the Catalyst 6500 Series switch, the Cisco ACE was evaluated in key areas: Layer 4 and Layer 7 Load Balancing performance, SSL performance, device scalability, availability, and security. The Cisco ACE showed itself to be superior in all performance tests conducted compared to F5 BIG-IP 8400. Targeted for enterprise and service provider customers, the Cisco ACE offers data center owners the potential to lower overall capital and operating expenses based on features, performance, and measured power consumption under load.

The Cisco ACE demonstrated features and scalability not available in other solutions including the ability to create virtual partitions (up to 250 per module), separate administrative logins per virtual partition combined with customizable Role-Based Access Control (RBAC) for granular administrative and user access, hierarchical domains to further enhance security control and maintenance access; and architectural scalability.

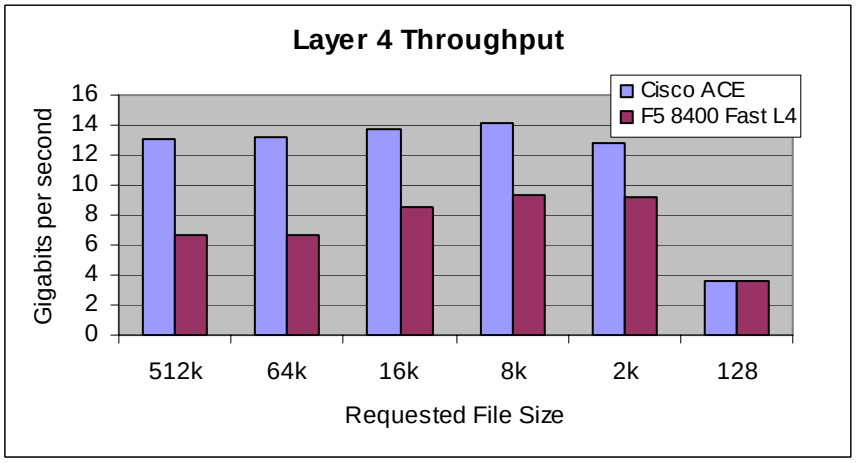
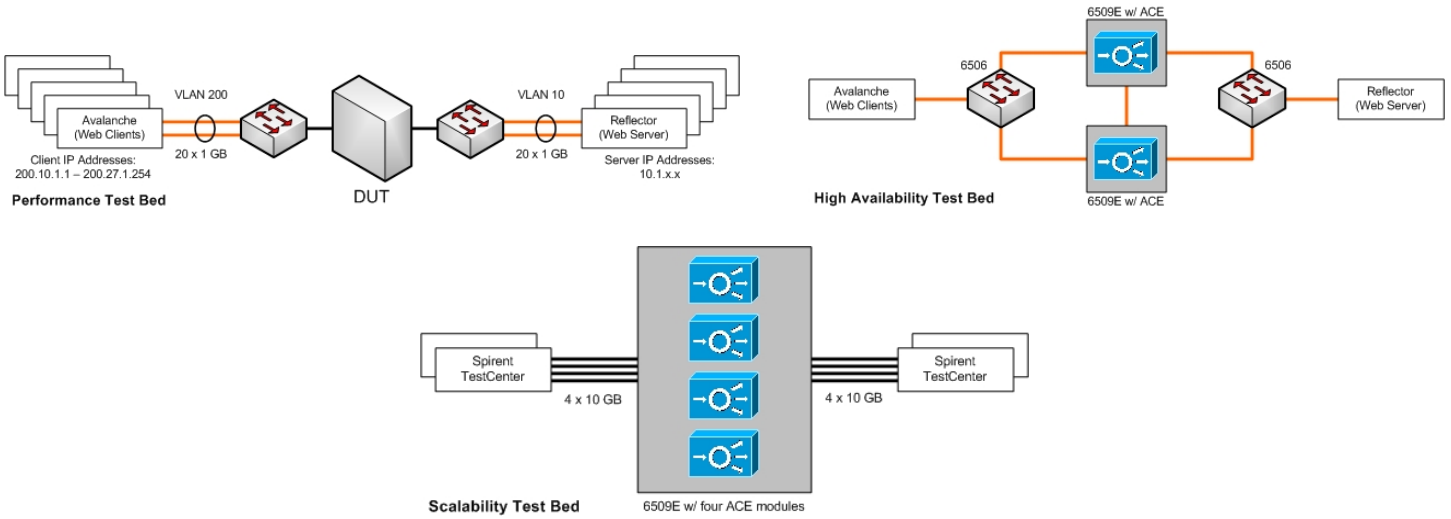


Chart 1: Results of Layer 4 Throughput for Cisco ACE and F5 BIG-IP 8400 w/ F5 FastL4 profile

Competitive Testing Note: The tests and test methodology that produced these results were proposed by, co-developed with and/or influenced by the vendor sponsoring the review. Miercom assured their fair and accurate application. These are not the only results that should guide a product selection.

Test Bed



How we tested: Three test environments were created to conduct a wide range of Performance, Scalability, High Availability, and Security tests. The performance, security, virtualization and Role-based access control tests were conducted on the performance test bed. Both the Cisco ACE module, software release A1.3, mounted in a Cisco Catalyst 6509 chassis with a Sup720-3BXL and the F5 BIG-IP 8400 with version 9.2.3 were tested in this environment. The Spirent Web Avalanche 2700C and Reflectors 2700C, software release 7.51, were used to generate real application traffic from 2520 clients to twenty servers. Both the Spirent Avalanches and Reflectors were connected to a 48 ports GigE (WS-X6748GE-TX) line card on the Cisco Catalyst 6509 switch. The F5 BIG-IP 8400 two 10 GigE interfaces were connected to a 4-port 10GigE (WS-X6748GE-TX) line card on the Cisco Catalyst 6509 switch. Both the Cisco ACE module and the F5 BIG-IP 8400 were configured in routed-mode with round-robin load balancing. The Spirent Reflectors (servers) default gateway was set to the IP address configured on the DUT. The F5 BIG-IP 8400 was configured with FastL4 and FastHTTP performance profiles to obtain the maximum performance.

The Scalability test environment was used to demonstrate linear scalability of the Cisco ACE module. Four Cisco ACE modules, software release A1.3, were mounted in a Cisco Catalyst 6509 chassis with a Sup720-3BXL. The Spirent TestCenter, software release 1.30, generated bi-directional traffic via 8 x 10 GigE ports connected to two 4-port 10GigE (WS-X6748GE-TX) line cards on the Cisco Catalyst 6509 switch. The Cisco ACE module was configured to perform round-robin load balancing for all tests.

The High Availability test environment was used to evaluate the Cisco ACE module fail-over and fail-back capabilities. Two Cisco ACE modules, software release A1.3, were mounted in separate Cisco Catalyst 6509 chassis with a Sup720-3BXL. A dedicated VLAN was setup between the two Cisco ACE modules for all redundancy-related traffic. The Spirent Avalanche 2700C and Spirent Reflector 2700C, software release 7.51, were connected to a Cisco Catalyst 6506 Layer 2 switches and generated application traffic during the fail-over and fail-back tests.

Performance Tests: The Spirent Avalanche Commander, software release 7.51, was used for the performance tests.

- Layer 4 Connections per Second (CPS) Tests measured how rapidly new connections could be created by the Device Under Test (DUT) for various server response file sizes without errors. The tests set up new connections and completed a full transaction with graceful TCP termination.
- Layer 4 Throughput tests measured the DUT's maximum throughput for various server response file sizes.
- Layer 4 concurrent tests measured how many successful concurrent connections the DUT can sustain without any error.
- Layer 7 CPS Tests measured how many new connections could be setup by the DUT for various server response file sizes without any error. Unlike the Layer4 CPS tests, the DUT was required to perform TCP termination and analyze at least the first data packet after the TCP setup (SYN/SYN_ACK/ACK) in order to make an intelligent load balancing decision. The F5 BIG-IP 8400 was tested with both Standard and FastHTTP performance profiles to identify performance differences between the two profiles.
- Layer 7 Throughput tests measured the DUT's maximum throughput for Layer 7 traffic.
- Layer 7 Concurrent Connection tests measured how many concurrent connections the DUT can sustain without any error for Layer 7 traffic. The Spirent Reflector systems were configured to delay their response 60 seconds to keep the connections open as additional connections were created. At the end of the 60 seconds delay, the connections were closed without additional delay or error.
- SSL Bulk encryption tests stressed the symmetric encryption and decryption performance and measured the maximum SSL throughput of the DUT. The DUTs were configured to terminate the SSL connections.
- TCP Reuse tests measured the number of client HTTP transactions versus the actual TCP connections established on the Spirent Reflectors using the Spirent Avalanche Command GUI. The number of client HTTP transactions and server transactions were matched in order to ensure that all transactions were successful without any error.

Scalability Tests: The tests determined the maximum bi-directional load-balanced throughput of multiple Cisco ACE modules. The Spirent TestCenter GUI was used to measure the throughput of up to four Cisco ACE modules that were incrementally brought online within a Cisco Catalyst 6500 chassis.

High Availability Tests: For the first test a "`ft`" (fault-tolerant) switchover command was issued to the Cisco ACE module during the generation of 100 HTTP transactions from the Spirent Avalanche. In the second test, the external VLAN interface configured on the Catalyst 6509 was manually brought down during the HTTP transactions. The Spirent Avalanche Commander was used to monitor any unsuccessful transactions during the fail-over.

Datacenter Efficiency Tests: Using a CYBERSwitching Dualcom external power management devices the actual power consumed by the DUTs during the load was measured.

Virtualization Tests: A simple script was used to create 250 virtual partitions each with dedicated resources on the Cisco ACE module. Management access and load balancing configurations were manually created on several virtual partitions. Manually logged in to virtual partitions through dedicated management interfaces and verified the configurations.

Role-based Access Control (RBAC) Tests:
- RBAC tests: Several administrative user roles were created with appropriate pre-defined roles on the Cisco ACE module and F5 BIG-IP 8400. In addition, a user with custom role was created on the Cisco ACE module to restrict access to only selected security functions on the Cisco ACE module. Commands were issued to verify the scope of access and functions available in the various roles.
- Hierarchical Management Domain: Created two separate management domains each with a VIP and real server objects inside a virtual partition of the Cisco ACE module. Two administrative user roles were created with access to a specific domain. Commands were issued to verify the scope of access and functions within a management domain.

Security Tests: Security attacks and real application traffic were generated from the Spirent Avalache servers. The Spirent Avalanche commander GUI was used to monitor the number of security attack transactions that were successfully blocked by the DUTs.

Overview

The Cisco Application Control Engine (ACE) is a multi-service Cisco Catalyst 6500 series switch module designed for application delivery with features of intelligent server load balancing, server off-load, SSL acceleration, application acceleration, and network security for enterprise data centers and service providers. Miercom conducted a wide range of tests on both the Cisco ACE module with software release A1.3 and the F5 BIG-IP 8400 with v9.2.3 software. The testing and evaluation focused on several key areas: Scalability, Delivery Performance, Availability, Data Center Efficiency and Management Features.

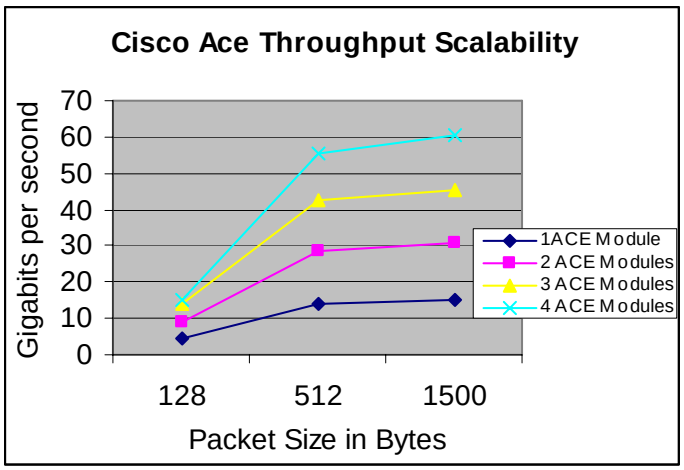


Chart 2: Cisco ACE Scalability test results

Scalability

The scalability test was performed on the Cisco ACE using Spirent TestCenter. A single Cisco ACE module achieved a maximum bi-directional load-balanced throughput of 15.3 Gbps. Cisco ACE also demonstrated linear scalability by delivering close to the theoretical limit of 64 Gbps using four ACE modules in a single Catalyst 6500 chassis. In these tests, Spirent TestCenter was used to measure the throughput of up to four Cisco ACE modules that were incrementally brought online within the Catalyst 6500 chassis. As shown (Chart 2. and Fig. 1) the maximum throughput increased linearly as each Cisco ACE module was brought online. In addition to the linear scalability tests across four Cisco ACE modules, the second scalability test demonstrated how the Cisco ACE enables scaling from 4 Gbps to 8 Gbps to 16 Gbps of throughput on a single Cisco ACE module using only a software license upgrade. The F5 BIG-IP 8400 can not be upgraded in a modular fashion nor does it support a similar license upgrade feature.

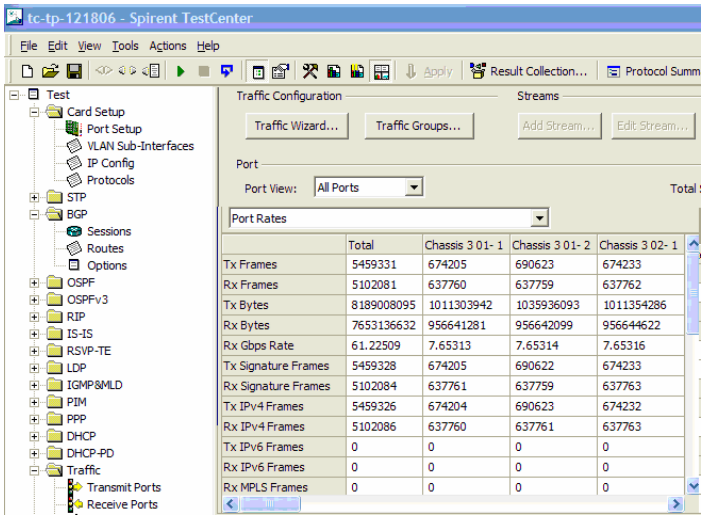


Figure 1: Screenshot of four ACE modules with 1500 byte traffic at 60+ Rx Gbps rate.

Performance Results

L4 CPS: The Layer 4 connections per second (CPS), concurrent connections, and throughput tests for various server response file sizes were performed on the Cisco ACE and the F5 BIG-IP 8400 (Chart 3). Across the file sizes tested, the

Cisco ACE demonstrated higher CPS ranging from 45% to better-than-parity compared to F5 BIG-IP 8400. At the largest server response file size (64K bytes), Spirent Avalanche reached its CPS (~4.5K per device) generation limit inhibiting the ability to determine the maximum CPS limit for large server response file size on the Cisco ACE module. The F5 BIG-IP 8400 was configured with the FastL4 profile to obtain its maximum performance. However, as stated by F5, the FastL4 profile has several feature trade offs such as no HTTP/TCP optimizations, no OneConnect, and no compression.

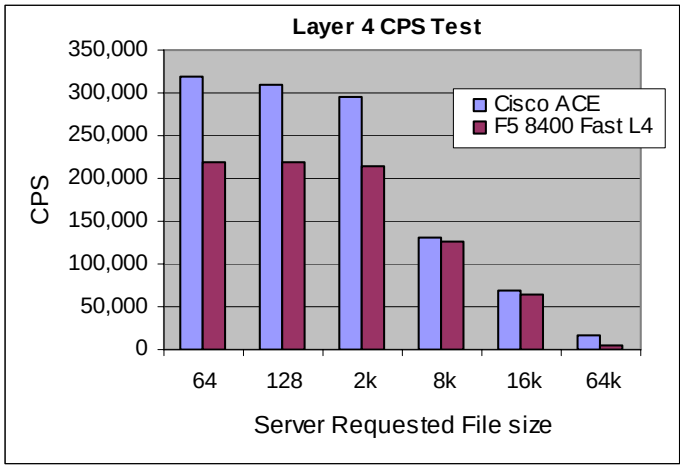


Chart 3: The Cisco ACE module for the 6500 chassis shows superior ability to create and process connections across a range of transmitted file sizes.

L4 Concurrent: The Layer 4 Concurrent test results showed that the Cisco ACE handled almost 4 million bidirectional connections, compared to 1.9 million bidirectional connections for the F5 BIG-IP 8400 (Chart 4). Each of these connections represents both the client-to-DUT as well as the DUT-to-server side of the connection.

L4 Throughput: The Layer 4 throughput test at different response file sizes shows consistently stronger performance by the Cisco ACE over the F5 BIG-IP 8400. From files sizes of 512K down to 2K (Chart 1, cover), the Cisco ACE maintained a performance increase of 95% to 38% over the F5 BIG-IP 8400. Parity occurred at 128 byte size file from the higher overhead typical of processing large numbers of small files.

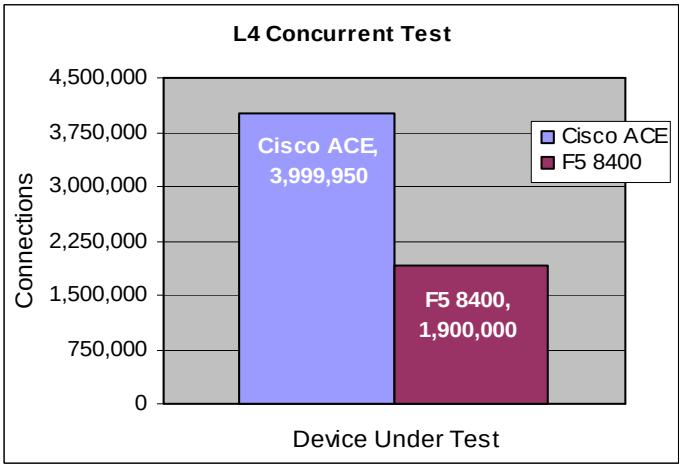


Chart 4: Number of Concurrent Layer 4 Connections sustained by DUTs

L7 Results: These Layer 7 tests differ from the Layer 4 series, as the traffic generated requires the device under test (DUT) to perform TCP termination, analyzing at least the first data packet after the TCP setup sequence (SYN / SYN_ACK / ACK) in order to make an intelligent switching decision. As a note for this test series, the F5 BIG-IP 8400 can run in two relevant modes, Standard or Fast HTTP. F5 describes the difference in the two modes as follows: The Standard Mode can fully utilize all of the features available in the 8400 while the Fast profile provides better performance with limitation in the feature set such as no session persistence, no compression, limited iRules support and no TCP optimization. The testing performed has verified the performance trade-off to other services when F5 Fast HTTP profile is used. The L7 CPS test with F5 standard HTTP profile can handle only up to 30K CPS even for a small server reply size. As the server file response size increased, the F5 BIG-IP performance with standard HTTP profile further degraded. Hence, the L7 CPS test measurements were limited to using only the Fast HTTP profile as it provided the best results, compared to F5's standard profile tradeoffs.

L7 CPS: The Layer 7 Connection per Seconds (CPS) results (Chart 5) show the continued trend of the faster metrics of the Cisco ACE over the F5 BIG-IP 8400. Even using the Fast HTTP profile for the F5 BIG-IP 8400, the Cisco ACE showed better performance by 15% with the 64 byte response file size, 6% with 128 bytes, and 50% plus over the remaining file sizes. It also

was noted that the F5 BIG-IP 8400 received a small number of errors over the last four file sizes, compared to zero for the Cisco ACE.

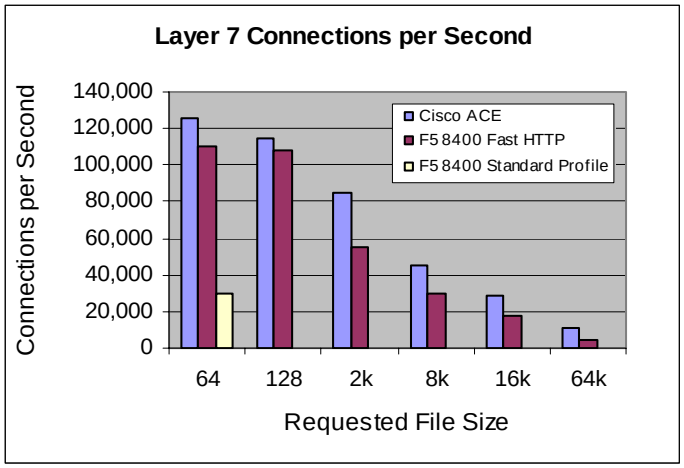


Chart 3: L7 CPS over Various File Sizes

L7 Throughput: In Layer 7 throughput results (Chart 6), from 512K byte file size down to 2K bytes, the Cisco ACE produced a consistent 12 to 13 Gbps rate. At 128 byte file size, the Cisco

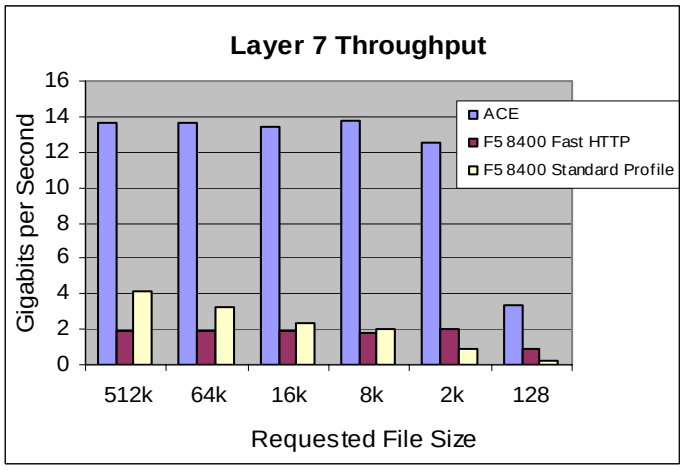


Chart 4: L7 Throughput over Various File Sizes

ACE throughput was 3.4 Gbps. The F5 BIG-IP 8400, using the Fast HTTP profile, performed fractionally of the level seen on the Cisco ACE, with throughput at approximately 2 Gbps across all of the file sizes. The tests were repeated on the F5 BIG-IP 8400 with the standard configuration profile, which did improve the throughput marginally, with results ranging from a high of 4 Gbps at 512K down to approximately 1 Gbps at 2K, and results at 128 byte file size reaching less than 0.5 Gbps. This is three times the L7 performance of the F5 BIG-IP 8400.

L7 Concurrent Connections: The Layer 7 concurrent connections test showed the Cisco ACE surpassing the F5 BIG-IP 8400 with 69% margin of improvement, sustaining 525,000 concurrent connections compared to a maximum of 310,000 concurrent connections for the F5 BIG-IP 8400.

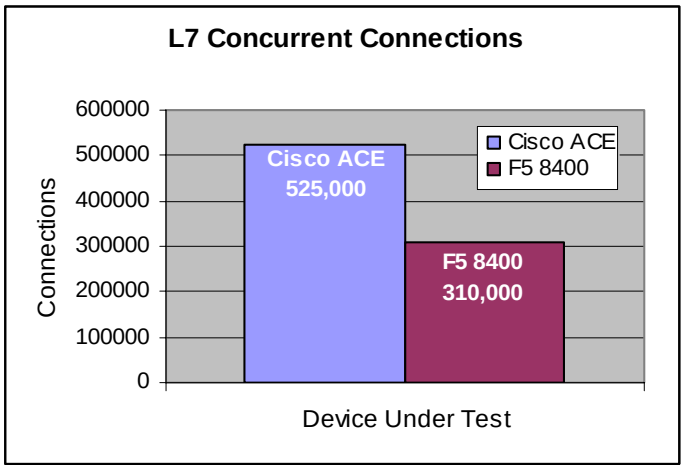


Chart 5: L7 Concurrent Connections

SSL Test Results: SSL Bulk encryption testing was performed on both Cisco ACE and F5 BIG-IP 8400 to stress the symmetric encryption performance and verify the maximum SSL throughput of each device. The Cisco ACE results showed that it was able to deliver a 370% higher throughput compared to the F5 BIG-IP 8400 for SSL traffic.

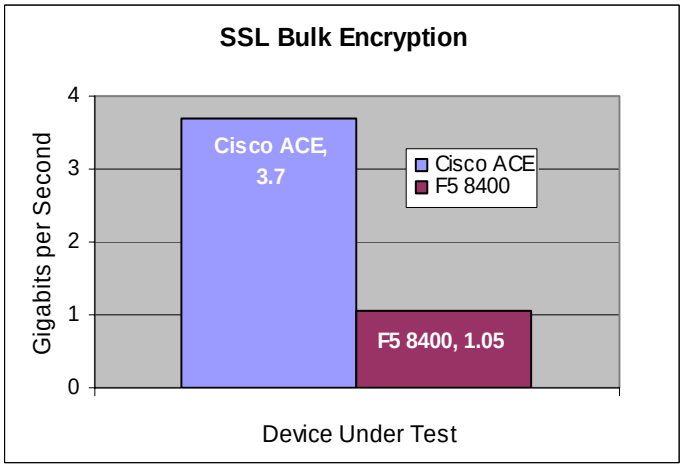


Chart 6: SSL Bulk Encryption

Data Center Efficiency

Given Cisco ACE module draws power from the backplane of Catalyst 6500 series switch, the Catalyst 6500 "show power" command was used to measure maximum allocated power to the Cisco ACE module during load. The externally measured power consumption by the Cisco ACE module was lower than the maximum allocated power. A CYBERSwitching Dualcom external power management device was used to measure the actual power consumption for F5 BIG-IP 8400 during the load. The results show that the Cisco ACE maximum allocated power was only 220 Watts, 61% of the 363 Watts consumed by the F5 BIG-IP 8400. This translates to an estimated 751 BTUs for the Cisco ACE module compared to 1239 BTUs for the F5 BIG-IP 8400. This is further magnified as throughput or customer isolation requirements increase. To achieve 12 Gbps of L7 throughput would require a single Cisco ACE module compared to three F5 BIG-IP 8400 operating in standard configuration. The total power consumption would rise to 1089 watts for F5 BIG-IP 8400 while remaining constant for Cisco ACE. Similarly, should three customers require isolated services, they all can be accommodated in a single Cisco ACE module (see virtualization discussion below) but would require three separate F5 BIG-IP 8400 devices.

Operational Benefits

Virtualization: The Cisco ACE virtual partitioning with role-based access control (RBAC) was demonstrated. Tests showed that a single Cisco ACE can provide up to 250 virtual device partitions each with dedicated resources, configurations and direct management login. It was also demonstrated that the virtual partitions are completely independent in terms of management, resources, configuration, RBAC, routing tables, and functionality. As an example, each partition has a separate management interface that is logged into directly, and separate from the high level device admin logins.

Role Based Access Control (RBAC), a Cisco feature that meshes with the administration of the virtual partitions, was demonstrated several times by creating a custom user role and leveraging pre-defined roles to restrict access to specific functions. Commands were issued to verify the scope of access and functions available in the various roles. RBAC has many control features that allow individual user roles and template roles to be created to segregate the update and maintenance role of network personnel. By defining and limiting the overlap of user creation and update functions, network admin and security functions can be assigned and accomplished with planned workflow roles.

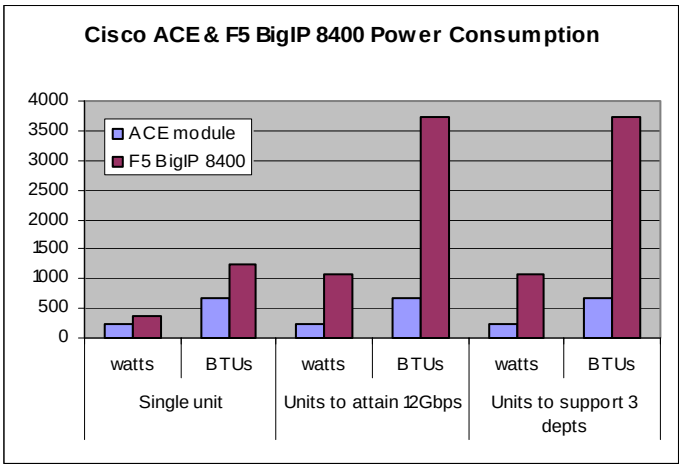


Chart 7: Power Consumption

In addition, Cisco ACE's hierarchical domain feature was demonstrated. It enabled assignment of more granular responsibilities so that IT functional groups are exposed to only specific functions or commands when multiple applications are hosted on the same physical device or virtual device partition. In contrast, F5 BIG-IP 8400 with v9.2.3 only provided three pre-defined roles and lacked the capability to define device-level virtual partitions and grant granular responsibilities to administrators.

High Availability: The Cisco ACE demonstrated no impact to application availability in the simulation of device failure. A fail-over and fail-back between two Cisco ACE modules was performed at the virtual partition level to demonstrate this unique capability. The Cisco ACE active virtual partition was forced to fail-over to the standby virtual partition using a "`ft`" (fault-tolerant) switchover command during the generation of 100 HTTP transactions from the Spirent Avalanche. The test results (Figure 2) showed that all 100 transactions were successful

without any error. A second successful Cisco ACE fail-over scenario was demonstrated by tracking the failure of a VLAN. This test showed that the Cisco ACE could track and detect failures of other devices (example: MSFC on the Catalyst 6500) and perform fail-over from the active virtual partition to the standby virtual partition if the tracked device became unresponsive. In the High Availability setup, the Cisco ACE active virtual partition automatically synchronized any new configuration or changes made in the existing configuration to the standby virtual partition. The High Availability tests were not conducted on the F5 BIG-IP 8400.

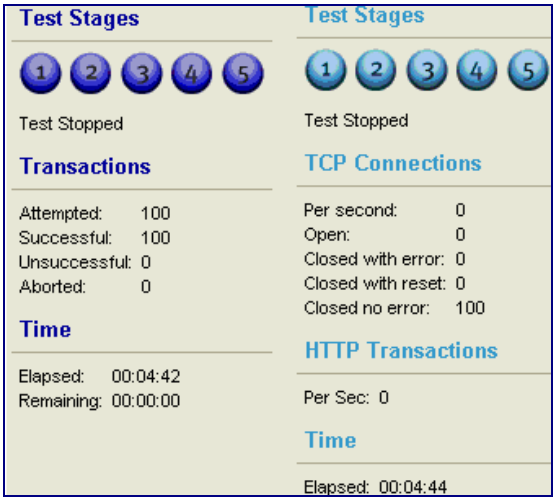


Figure 2: Failover test screenshot of Avalanche Commander Monitor test results screen

TCP Reuse: Cisco ACE with the TCP Reuse feature significantly reduced the number of connections established to the server. As shown in Chart 8, Cisco ACE established only 400 connections to real servers for 80,000 client transactions. This Cisco ACE feature freed up CPU resources on servers to establish and tear-down TCP connections. F5 BIG-IP 8400 does not support its equivalent feature called OneConnect when the Fast L4 profile is enabled.

Configuration Rollback: The Cisco ACE configuration checkpoint and rollback service was demonstrated at the virtual partition level. The test results showed that up to ten maximum snapshots of running configuration could be taken per virtual partition and any of them could be restored. This service helps customers to immediately revert to the last known stable configuration in case any unforeseen problems occur due to new configuration changes.

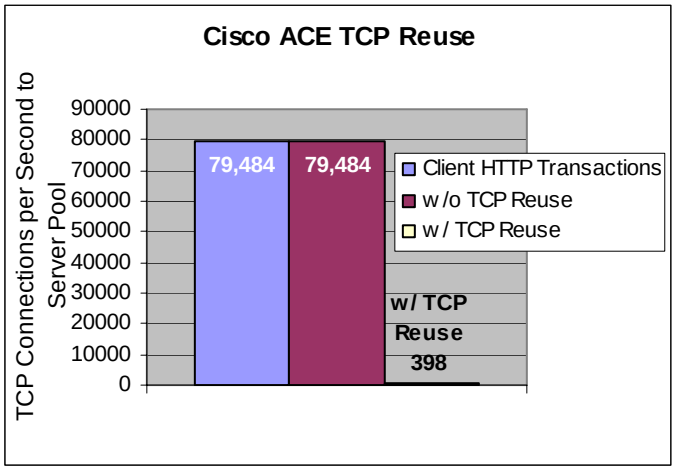


Chart 8: Cisco ACE TCP Reuse test results

Integrated Security

Application security tests were performed on the Cisco ACE and F5 BIG-IP 8400 using Spirent Avalanche devices. With a simple configuration, Cisco ACE successfully blocked and nullified various security attacks such as HTTP tunnel, Nimda, Obfuscated Nimda, and Xmas Tree attack. The F5 BIG-IP 8400 required custom programming of F5 iRules using TCL to protect against these attacks. Cisco ACE also performed many TCP/IP/ICMP checks such as TCP/IP header validation, automatic anti-spoofing, illicit IP addresses validation, overlapping fragments validation, ICMP request and response matching by default during all performance tests. No performance degradation of Cisco ACE was seen when these capabilities were enabled.

Conclusion

The Cisco ACE module for the Catalyst 6500 switch chassis showed superiority to the F5 BIG-IP 8400 switch. The Cisco ACE module demonstrated better performance in L4, L7 and SSL bulk encryption testing. It also showed linear scalability for throughput and connection processing across multiple modules in a single switch chassis. Lower power consumption along with innovative management features such as virtualization, RBAC, hierarchical domains and configuration rollback earned the Cisco ACE module the Miercom Performance Verified certification.

Miercom Performance Verified

Based on Miercom's examination and testing of scalability and performance throughput of these systems' configuration, operation and features, as described herein, Miercom hereby issues the Performance Verified certification for the product in this report. Miercom certifies the following key observations made during this review:

- **The Cisco Catalyst 6500 Application Control Engine (ACE) module demonstrated superior speed, throughput and scalability compared to the F5 BIG-IP 8400 switch in comprehensive performance tests**
- **The Cisco ACE provided linear scalability for throughput and connections with multiple modules in a single Catalyst 6500 switch**
- **The Cisco ACE provides improved data center efficiency through lower power consumption and heat output**
- **The Cisco ACE eases and accelerates provisioning and management with unique features including, Hierarchy Domain, RBAC, Virtualization, and Configuration Rollback**

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