

Radware AppDirector x08 and x16 Application Switches

Performance Evaluation versus F5 Networks BIG-IP 1600 and 3600

Premise & Introduction

Next-generation applications continue to evolve, generating more complex transactions that require deeper inspection levels. Such applications require application delivery platforms to operate at full capacity at Layer 7, enforcing multiple user and application-based policies, while processing transactions with the fastest response time to meet SLA requirements and to assure Quality of Experience, even when under attack.

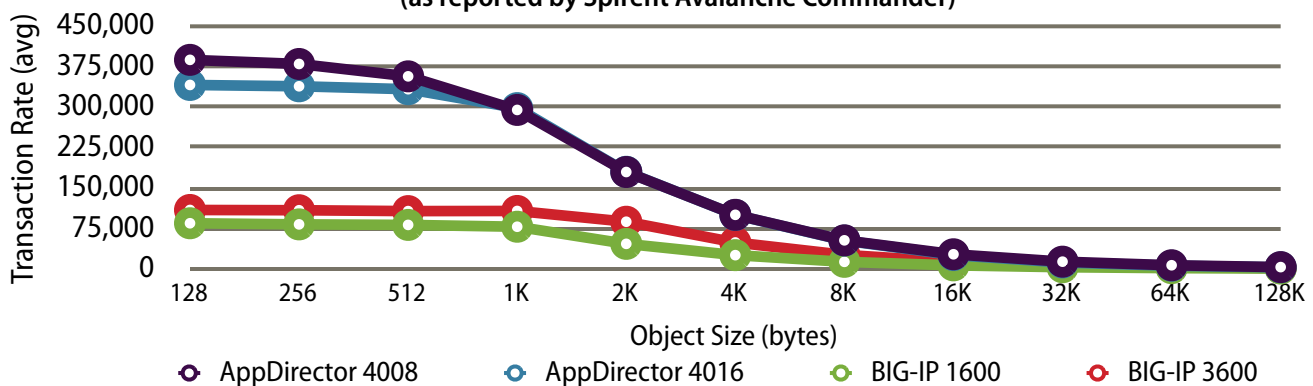
Radware commissioned Tolly to validate the performance of the AppDirector 4016 and the newly-introduced 4008 vs F5's newly-introduced BIG-IP 1600 and 3600 running F5's newest version, 10.0. This comes two years after the release of the Tolly report showing AppDirector x16's superior performance over the F5 BIG-IP 1500, 6400 and 6800 platforms.

The project measured the throughput, transaction rates and response times of the systems while processing layer 7 transactions with and without SSL termination. Tests also measured system performance while the systems were subject to a number of denial-of-service attacks.

Test Highlights

- 1 Exhibits over 387K Layer 7 transactions per second (tps) – more than 3.5X the transactions handled by F5's BIG-IP 3600 when handling 128-byte objects, and 2.5X better performance on average for all object sizes
- 2 Exhibits an average of 52X and 42X faster response time than F5's BIG-IP 1600 and BIG-IP 3600, respectively, for all layer 7 objects sizes, and up to 219X faster response time for 512-byte objects
- 3 Delivers over 3.7 Gbps of consistent throughput, when handling 10 HTTP transactions per connections and object sizes of 1 Kbyte and larger
- 4 Delivers over 20,000 SSL connections per second (cps), which is 150% of the SSL processing capacity of the BIG-IP 3600 and 340% of the BIG-IP 1600
- 5 Combats 2X ICMP and SYN attack packets vs. BIG-IP 1600 and BIG-IP 3600 respectively, while sustaining 1 Gbps of throughput with no performance degradation

Layer 7 Transaction Rate at Various Object Sizes
HTTP1.1 Protocol with 10 Requests per Connection
(as reported by Spirent Avalanche Commander)



Note: Each vendor's lower end device was tested with 4 GbE ports, the higher end device was tested with 8 GbE ports.
Transactions calculated by multiplying connection rate by number of requests per connection.

Source: Tolly, January 2010

Figure 1




Executive Summary

Response time is an important metric that should be considered when evaluating application delivery solutions. Excessive response time (i.e., latency) results in slower application performance and can jeopardize time-sensitive transactions and negatively impact a company's bottom line. Radware's AppDirector consistently outperforms the BIG-IP platforms during Layer7 - transactions per second,

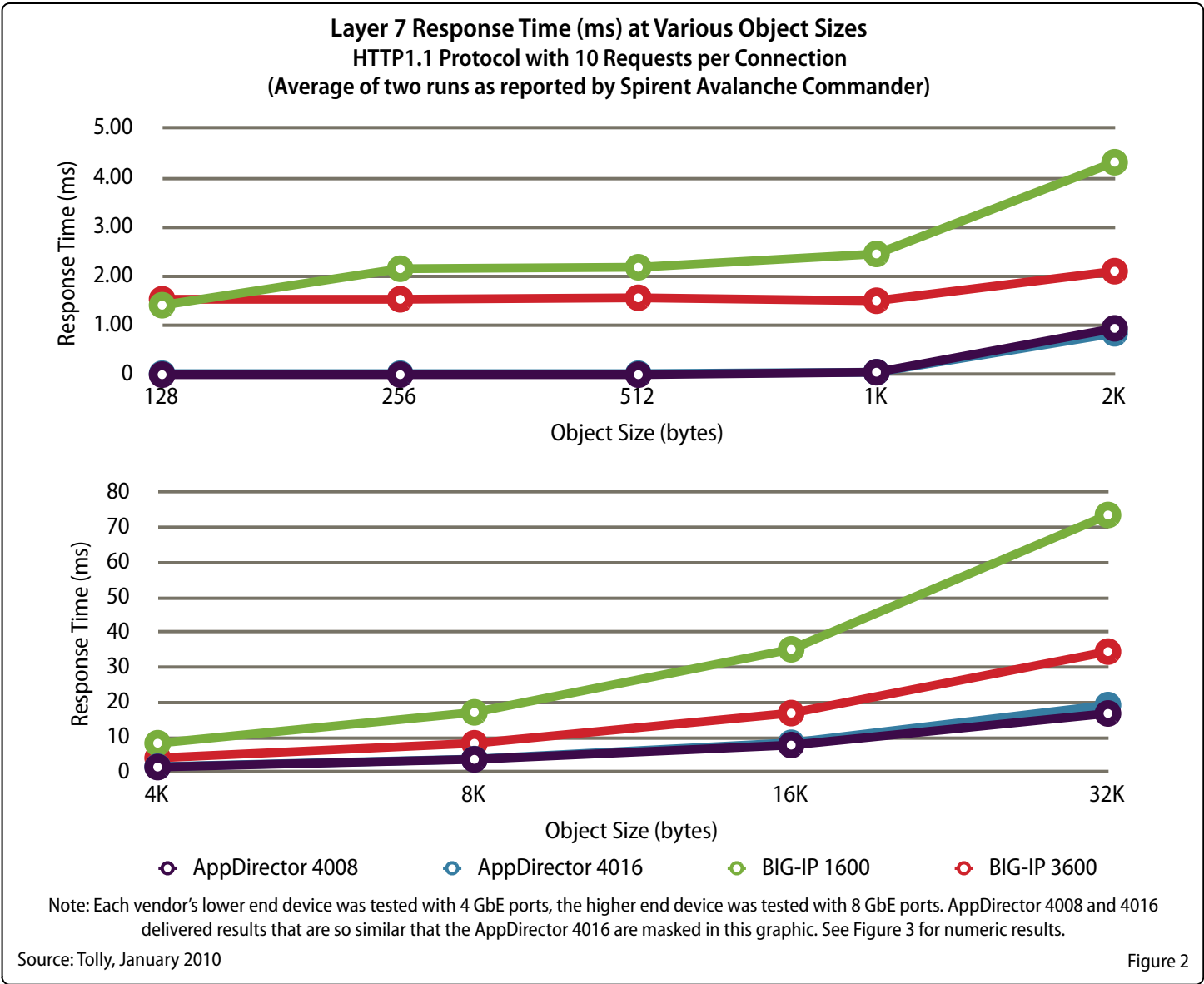
response time, throughput, SSL processing capacity and security tests.

AppDirector illustrated a clear advantage in Layer 7 transaction processing, SSL processing capacity, transaction processing under attack, while also presenting significantly faster response times. Excessive system latency can critically impair next-generation applications such as voice, video, Oracle applications, Microsoft applications, SAP and can even impact the most basic scenarios of HTTP traffic.

Radware Ltd
AppDirector
4008 and 4016
Layer 7
Application
Switch
Performance
Evaluation



Tested
January
2010





Higher Layer 7 Transaction Rate

Radware's AppDirector 4008 handled an average of 387,825 transactions per second (tps) when handling 128-byte object sizes with 10 requests per connection. This performance is 3.5X the 109,464 tps and 4.5X the 84,824 tps that F5's BIG-IP 3600 and BIG-IP 1600 were able to process, respectively. Radware's AppDirector 4008 handled an average of 294,926 transactions per second for an average throughput of 3.7 Gbps and average response time of 0.06 ms when handling 1K bytes objects. By contrast, F5's BIG-IP 3600 was only able to attain 107,614 transactions per second for an average throughput of 1.3Gbps and average response time of 1.5 ms. That

represents 24X faster response time for AppDirector and 2.7X the transactions processing power. On average, AppDirector processed 2.5X more transactions per second than BIG-IP 3600, and 4.2X more transactions per second than BIG-IP 1600 across all object sizes. See Figures 1 and 3.

Faster Response Time

At Layer 7 with 10 HTTP requests per connection, Radware's AppDirector 4008 achieved over 154 times faster response time and 3.5X more transaction per second than F5's BIG-IP 3600 while handling 128-byte object sizes. On average AppDirector, was 41.6X faster than F5's BIG-IP 3600 and 52X faster than F5's BIG-IP 1600, across all object sizes. See Figures 2 and 3.

Faster response time is critical to successfully delivering today's applications. Slow response time may result in long load time, poor user experience, customer dissatisfaction, and poor public perception, all of which can be directly related to a company's financial performance.

Higher SSL Processing Capacity

Radware's AppDirector also demonstrated superiority when processing SSL transactions. AppDirector 4016 was able to process 20,294 SSL transactions using a single, 1K object, outperforming F5's BIG-IP 3600 with only 13,708 transactions and F5's BIG-IP 1600 with only 5,916 transactions. See Figures 6 through 9.

Layer 7 Transaction Rate and Response Time (ms) at Various Object Sizes

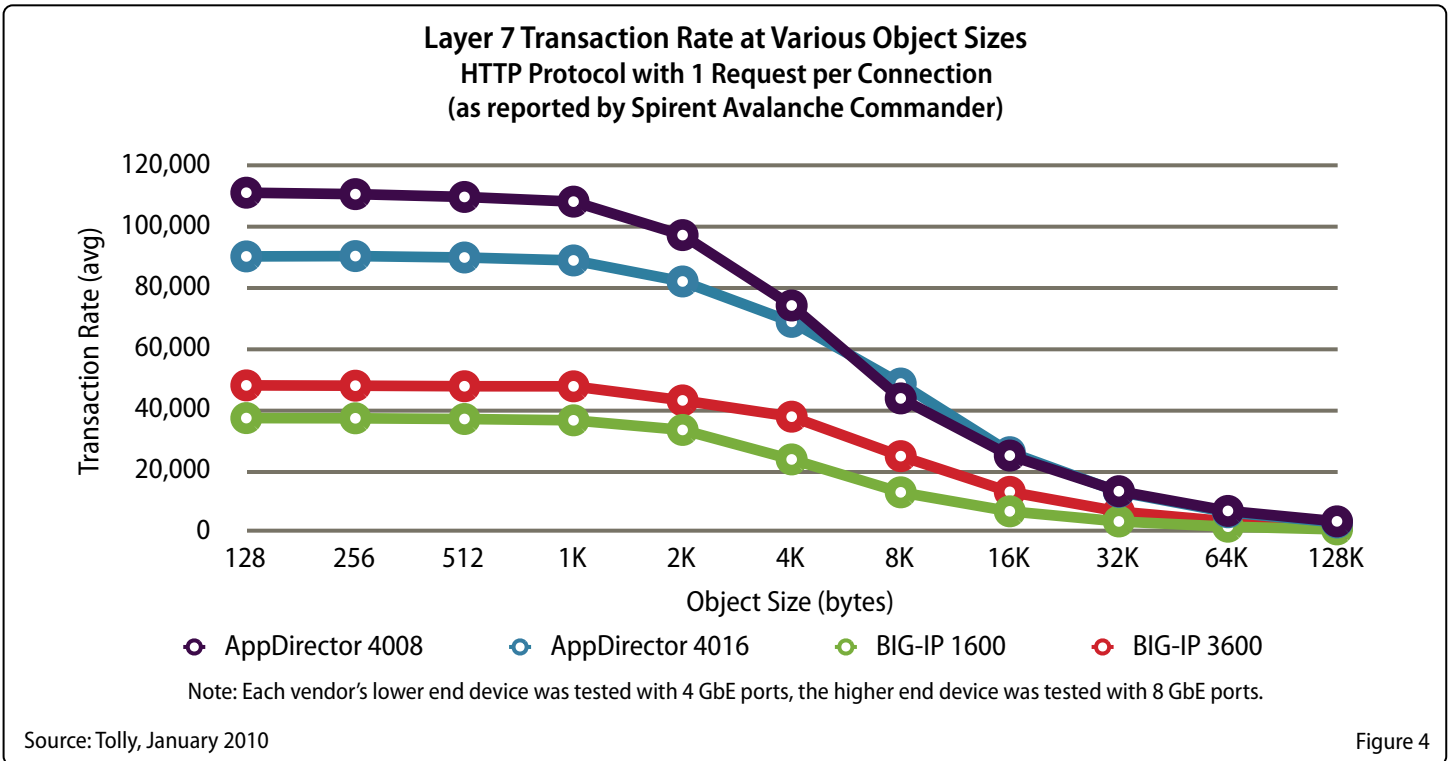
HTTP1.1 Protocol with 10 Requests per Connection

(Average of two runs as reported by Spirent Avalanche Commander)

System Under Test	Radware AppDirector 4008			Radware AppDirector 4016			F5 BIG-IP 1600			F5 BIG-IP 3600		
	Transaction Rate	Throughput (Mbps)	Response Time (ms)	Transaction Rate	Throughput (Mbps)	Response Time (ms)	Transaction Rate	Throughput (Mbps)	Response Time (ms)	Transaction Rate	Throughput (Mbps)	Response Time (ms)
128	387,825	2,115	0.01	341,287	1,860	0.03	84,824	463	1.42	109,464	597	1.54
256	380,191	2,462	0.01	339,819	2,200	0.03	82,740	536	2.16	108,971	706	1.54
512	357,265	3,063	0.01	333,406	2,858	0.03	81,758	701	2.19	107,371	921	1.57
1K	294,962	3,735	0.06	298,346	3,777	0.06	78,366	992	2.46	107,614	1,363	1.51
2K	179,868	3,834	0.95	180,277	3,843	0.85	46,638	995	4.32	87,646	1,868	2.11
4K	100,454	3,885	1.58	100,176	3,874	1.69	25,677	993	8.39	49,177	1,918	4.18
8K	53,164	3,900	3.78	52,683	3,864	3.85	13,275	974	17.22	26,170	1,931	8.37
16K	27,312	3,910	7.85	25,817	3,696	8.51	6,750	967	35.24	13,524	1,942	17.00
32K	13,602	3,842	16.90	12,099	3,418	19.29	3,310	937	73.66	6,905	1,954	34.59
64K	6,946	3,893	34.12	6,089	3,412	39.37	1,576	884	157.24	3,414	1,915	71.87
128K	3,502	3,911	68.82	3,105	3,468	78.54	783	874	319.57	1,748	1,953	569.37

Source: Tolly, January 2010

Figure 3



Greater Resistance to Denial-of-Service Attacks

Radware's AppDirector demonstrated superiority across not only Layer 7 tests, but also under extreme Denial of Service (DoS) attacks while maintaining the expected service level.

Under sustained 1 Gbps of legitimate traffic, and less than 3% traffic degradation, AppDirector 4008 managed to handle an average of 530,180 SYN attack packets or 968,993 ICMP attack packets. In comparison, F5's BIG-IP 3600 was only able to handle 317,580 SYN attack packets or 558,037 ICMP attack packets. Overall, AppDirector demonstrated 70% better attack mitigation capacity than F5's BIG-IP 3600 and BIG-IP 1600. See Figures 10 and 11.

Detailed Report Findings

The tests simulated common next-generation data center requirements, including up to 4 Gbps of throughput as well as the most common application

delivery services utilized in the next-generation data-center, including Layer 7 traffic redirection, SSL server offloading, as well as application delivery security protection against Denial of Service (DoS) attack. Figure 12 lists the details of the systems tested.

Layer 7 Performance

Engineers set out to measure HTTP load-balancing functions relative to two test scenarios: 1 and 10 requests per HTTP connections. In each test case the Tolly group engineers measured throughput, tps rate and response time in ms for the following object sizes: 128, 256, 512, 1K, 2K, 4K, 8K, 16K, 32K, 64K and 128K bytes.

Layer 7 with Ten Requests per Connection

This test measured the performance of systems executing 10 HTTP transactions over each connection. Each test run specified a different but fixed object size.

Running the test with a range of object sizes allows readers to map results to a wide range of real-life applications ranging from e-commerce business applications, business critical applications such as the Oracle E-business suite, Siebel CRM or IBM Lotus Domino or WebSphere, business collaboration applications such as Microsoft SharePoint, as well as voice, SIP-based applications.

Radware's AppDirector exhibited a significantly higher level of performance across all measured categories vs. F5 BIG-IP products, including transaction per second, throughput, and response time.

While testing Layer 7 performance with 10 HTTP requests per connection, engineers noted:

With respect to latency, Radware's AppDirector 4008 showed a substantial advantage retrieving 512-byte objects in just 0.01 ms compared with 2.19 ms for the

Layer 7 Transaction Rate and Response Time (ms) at Various Object Sizes
HTTP Protocol with 1 Request per Connection
(Average of two runs as reported by Spirent Avalanche Commander)

System Under Test	Radware AppDirector 4008			Radware AppDirector 4016			F5 BIG-IP 1600			F5 BIG-IP 3600		
	Object Size (bytes)	Transaction Rate	Throughput (Mbps)	Response Time (ms)	Transaction Rate	Throughput (Mbps)	Response Time (ms)	Transaction Rate	Throughput (Mbps)	Response Time (ms)	Transaction Rate	Throughput (Mbps)
128	111,451	927	0.59	90,521	753	0.95	37,416	314	3.41	48,159	404	2.49
256	110,978	1,037	0.62	90,628	847	0.95	37,348	351	3.43	48,056	452	2.50
512	110,053	1,259	0.66	90,165	1,032	0.96	37,118	427	3.50	47,875	551	2.54
1K	108,515	1,685	0.73	89,198	1,387	0.98	36,687	572	3.65	47,849	744	2.63
2K	97,522	2,359	0.95	82,291	1,994	1.06	33,523	812	4.05	43,222	1,047	3.06
4K	74,396	3,091	1.73	69,017	2,871	1.86	23,840	991	6.27	37,879	1,575	3.86
8K	43,880	3,345	3.76	48,770	3,720	3.15	13,030	994	12.76	24,918	1,900	17.39
16K	25,108	3,667	7.32	26,217	3,831	6.78	6,791	992	28.37	13,182	1,925	13.78
32K	13,397	3,823	14.66	13,172	3,760	15.14	3,461	988	62.65	6,712	1,915	30.68
64K	6,924	3,901	29.98	6,478	3,649	33.19	1,744	983	132.99	3,460	1,949	62.19
128K	3,494	3,912	62.30	3,126	3,500	71.57	856	958	282.82	1,744	1,953	134.18

Source: Tolly, January 2010

Figure 5

BIG-IP 1600 and 1.57 ms for the BIG-IP 3600. See Figure 3.

With respect to transaction processing power, Radware’s AppDirector 4008 handled an average of 387,825 tps when handling 128-byte object sizes, equaling 3.5X the 109,464 tps that F5’s BIG-IP 3600 was able to process.

Furthermore, with 1K-byte objects, Radware’s AppDirector 4008 handled an average of 294,926 transactions per second with an average throughput of 3.7 Gbps and average response time of 0.06 ms.

In comparison, the BIG-IP 1600 handled 78,366 Layer 7 transactions per second (tps) for a throughput of 992 Mbps and response time of 2.46 ms, and the BIG-IP 3600 handled 107,614 Layer 7 transactions per second (tps) for a throughput of 1.3 Gbps and response time of 1.5 ms.

AppDirector maintained its performance advantage across all object sizes and platforms with an average gain of up to 4.2X more transactions per second vs. BIG-IP 1600, and 2.5X vs. BIG-IP 3600 across all object sizes.

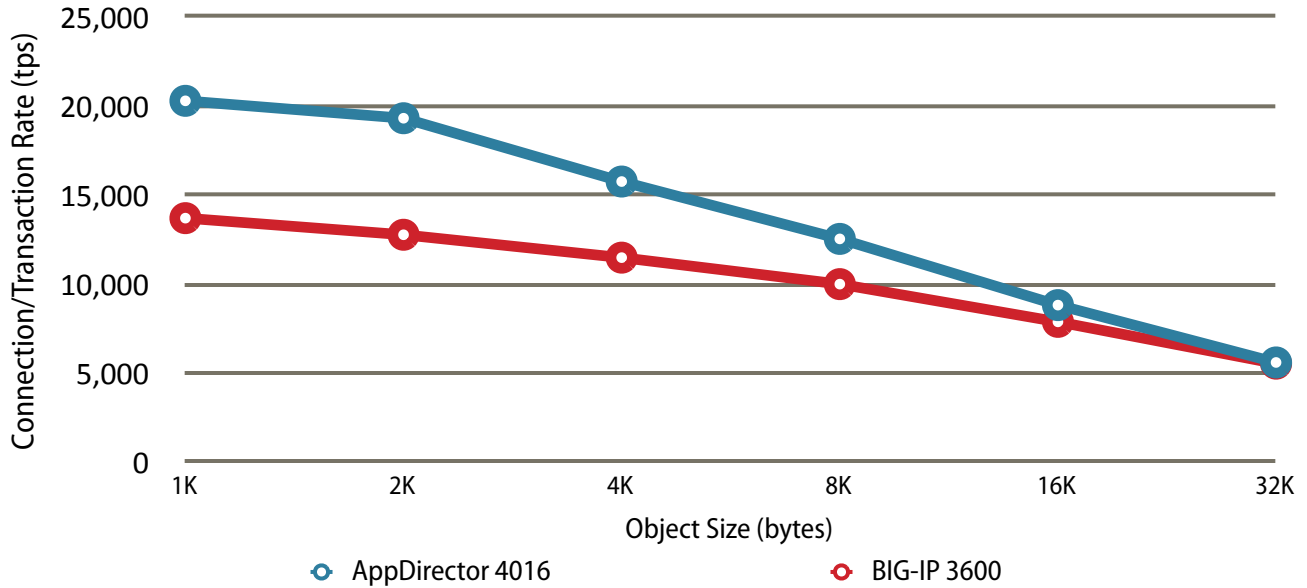
Layer 7 with One Request per Connection

Tolly Group engineers tested the most performance intensive function for each of the platforms, which included a setup and tear-down (FIN) of new TCP connections and handling one HTTP transaction for every new connection. In each test run a different object size was retrieved.

When handling transactions consisting of a single, 128-byte object, Radware’s AppDirector 4008 processed 111,451 Layer 7 tps. F5’s BIG-IP 1600 could handle only



Layer 7 SSL Offload Connection/Transaction Rate (tps) at Various Object Sizes
AppDirector 4016 vs BIG-IP 3600
 HTTPS Protocol with 1 Request per Connection
 (as reported by Spirent Avalanche Commander)



Source: Tolly, January 2010

Note: Tested with 8 Gigabit Ethernet ports.

Figure 6

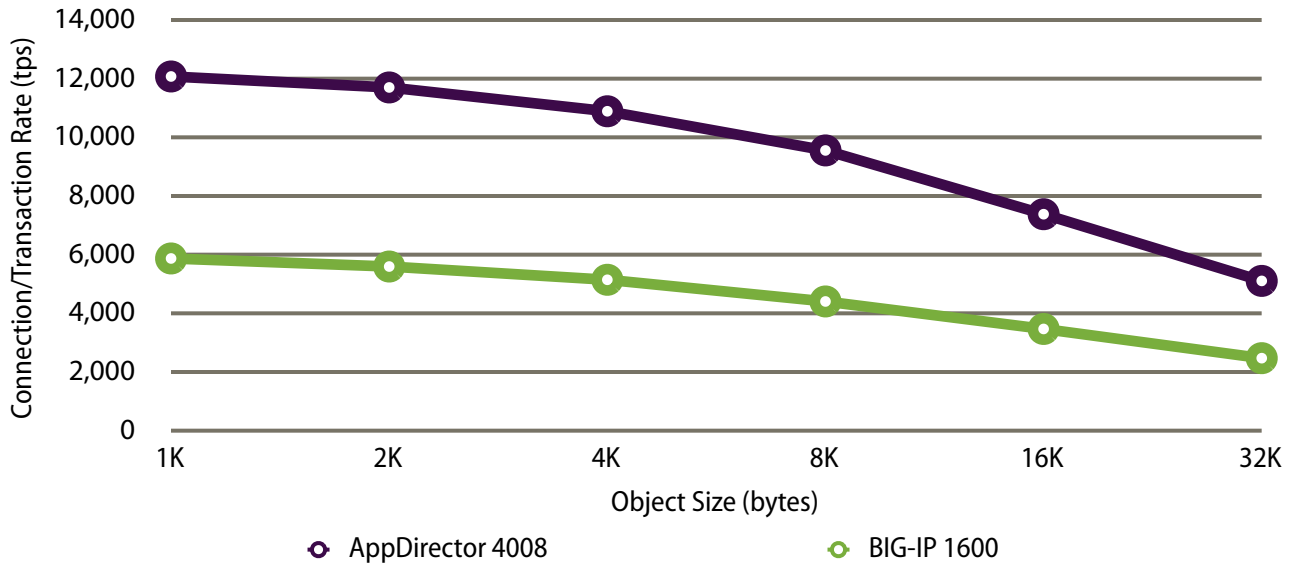
Layer 7 SSL Offload Connection/Transaction Rate at Various Object Sizes
AppDirector 4016 vs BIG-IP 3600
 HTTPS Protocol with 1 Request per Connection
 (Average of two runs as reported by Spirent Avalanche Commander)

System Under Test/ Object Size (bytes)	Radware AppDirector 4016	F5 BIG-IP 3600
1K	20,294	13,708
2K	19,317	12,775
4K	15,763	11,491
8K	12,543	10,004
16K	8,826	7,886
32K	5,607	5,540

Source: Tolly, January 2010

Figure 7

Layer 7 SSL Offload Connection/Transaction Rate (tps) at Various Object Sizes
AppDirector 4008 vs BIG-IP 1600
 HTTPS Protocol with 1 Request per Connection
 (as reported by Spirent Avalanche Commander)



Note: Tested with 4 Gigabit Ethernet ports.

Source: Tolly, January 2010

Figure 8

Layer 7 SSL Offload Connection/Transaction Rate at Various Object Sizes
AppDirector 4008 vs BIG-IP 1600
 HTTPS Protocol with 1 Request per Connection
 (Average of two runs as reported by Spirent Avalanche Commander)

System Under Test/	Radware AppDirector 4008	F5 BIG-IP 1600
Object Size (bytes)	Transaction Rate (tps)	
1K	12,120	5,916
2K	11,746	5,641
4K	10,934	5,189
8K	9,599	4,450
16K	7,425	3,513
32K	5,151	2,517

Source: Tolly, January 2010

Figure 9



37,416 tps and the BIG-IP 3600 could handle only 48,159 tps.

Radware's AppDirector delivered a response time of 0.73 ms when retrieving a 1-Kbyte object. In contrast, the BIG-IP 1600 was measured 3.62 ms and the BIG-IP 3600 was measured at 2.63 ms. These results demonstrate an advantage of up to 5X for AppDirector.

Radware's AppDirector advantage in latency remains consistent also in 32-Kbyte objects, where AppDirector exhibited a response time of 14.69 ms vs. the BIG-IP 1600 response time of 62.65 ms and the BIG-IP 3600's response time of 30.68 ms. On average, for all object sizes, AppDirector's response time was 4.5X faster than F5's BIG-IP 1600 and 3.1X faster than F5's BIG-IP 3600.

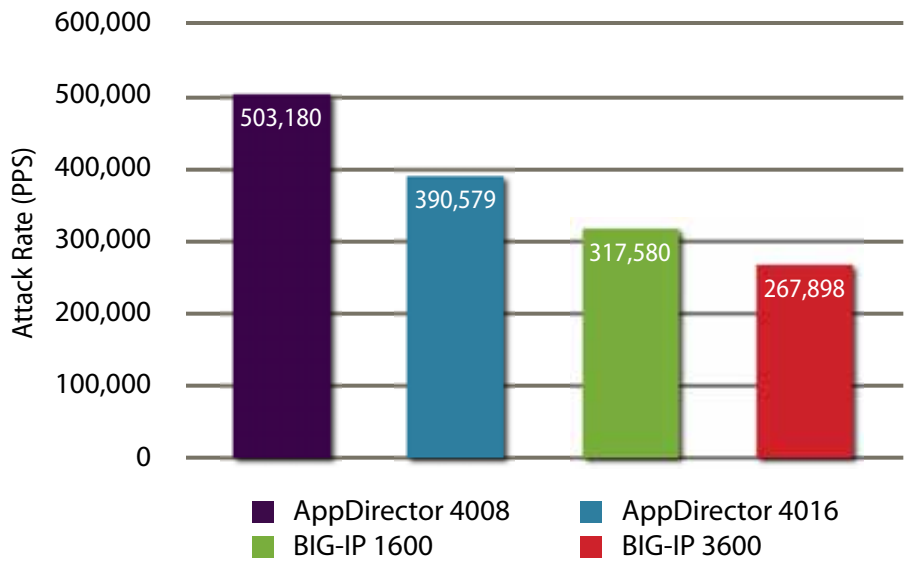
SSL Performance

The application delivery Controller's SSL acceleration function enables offloading of the CPU intensive encryption and decryption functions from Web servers and allows these servers either to process more transactions or to decrease the number of servers required to serve the entire HTTP load.

The SSL offloading test measures the most demanding performance scenario, using the HTTP 1.1 protocol with a single transaction per connection, and with no connection or keys reuse applied in the test. The RSA Encryption algorithm with a key length of 1024 was used to measure the performance of the systems.

The test shows that Radware's AppDirector 4016 outperformed the BIG-IP 3600 in the SSL tests reaching 150% of F5's result with a maximum number of 20,294 SSL transactions per second (one transaction per connection) versus a maximum of 13,708 SSL transactions per second for F5's BIG-IP 3600, all of this for a 1-Kbyte object size.

Distributed Denial of Service (DDos) Attack Resistance: SYN Flood
Attack Rate Resisted While Maintaining 1Gbps Legitimate Traffic Throughput
(as reported by Spirent Avalanche Commander)

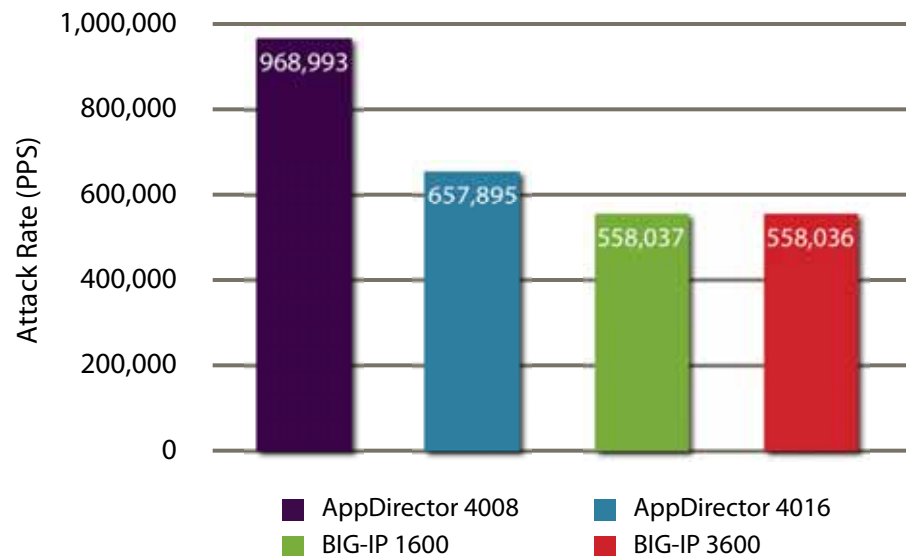


Note: Each vendor's lower end device was tested with 4 GbE ports, the higher end device was tested with 8 GbE ports.

Source: Tolly, January 2010

Figure 10

Distributed Denial of Service (DDos) Attack Resistance: ICMP Flood
Attack Rate Resisted While Maintaining 1Gbps Legitimate Traffic Throughput
(as reported by Spirent Avalanche Commander)



Note: Each vendor's lower end device was tested with 4 GbE ports, the higher end device was tested with 8 GbE ports.

Source: Tolly, January 2010

Figure 11

Systems Under Test (Configurations as Tested)

Vendor	Product	Software Version	System Memory (GB)	Network Interfaces	Acceleration Hardware	Throughput License Level
F5 Networks	BIG-IP 1600	10.0.1, Build 283.0 final	4 GB	Four 1000BASE-T	Yes	F5 does not use throughput license model
	BIG-IP 3600	10.0.1, Build 354.0 final	4 GB	Eight 1000BASE-T	Yes	
Radware, Ltd	AppDirector 4008 (OnDemand VL platform)	2.11.10	6 GB	Four 1000BASE-T	Yes	Unlimited (4 Gbps)
	AppDirector 4016 (OnDemand 2 XL platform)	2.11.10	6 GB	Eight 1000BASE-T	Yes	Unlimited (4 Gbps)

Note: Some switches have throughput limits that are artificially imposed by license level purchased by the customer. For Radware, the AppDirector product is built on the On Demand Switch (ODS) platform. The specific platform is listed in the table. The AppDirector 4008 supports up to eight GbE ports as the two management ports can also be used for traffic processing. The AppDirector 4016 supports up to twelve GbE ports. For more information on the Radware solutions, please visit: <http://www.radware.com/AppDirector>

Source: Tolly, January 2010

Figure 12

Radware's AppDirector 4008 outperformed the BIG-IP 1600 in the SSL tests by 200% and reached a maximum number of 12,120 SSL transactions per second (1 transaction per connection) versus a maximum of 5,920 SSL

transactions per second for F5's BIG-IP 1600, all of this for a 1 Kbyte object size.

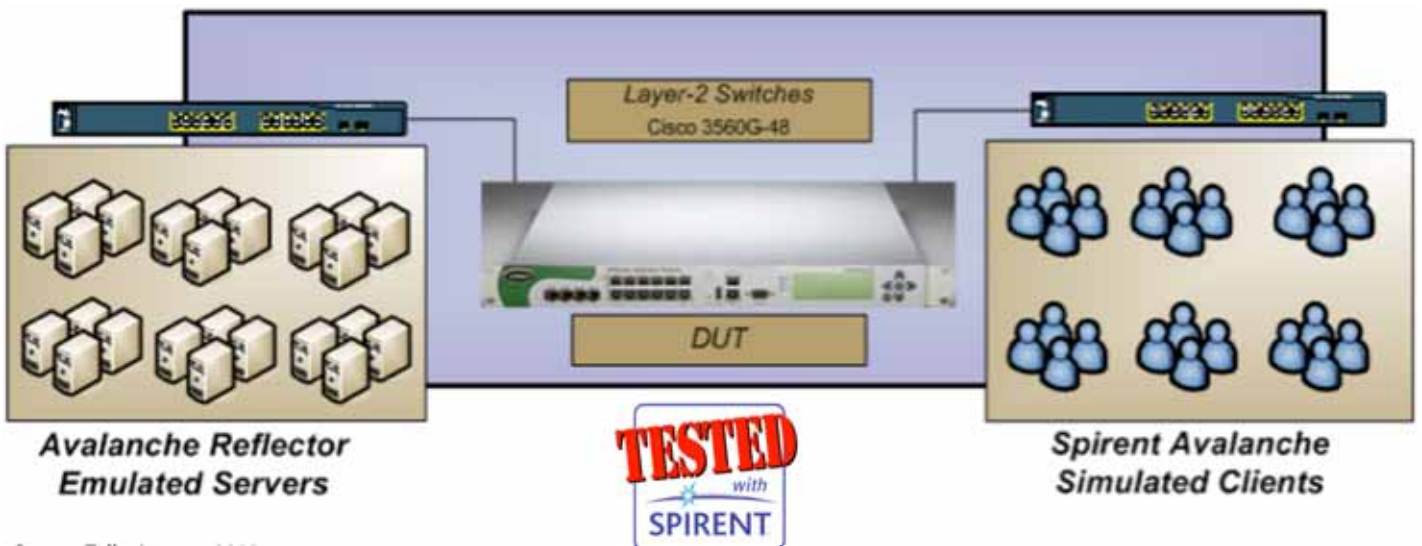
In addition, AppDirector also exhibited 2X throughput with an object size of 1-Kbyte, delivering up to 510 Mbps of throughput vs.

a maximum throughput of 337 Mbps for BIG-IP 3600 with the same object size.

Performance Under DDoS Attack

Guaranteeing that the application always

Test Bed Overview



Source: Tolly, January 2010

Figure 13



responds to requests originated by legitimate users when under attack is essential to preserving application availability. This test demonstrated the ability of the platforms to resist Distributed Denial of Service (DDoS) attacks while maintaining service continuity.

Tolly engineers tested the two solutions under two common DDoS attack scenarios and measured the solution capability to withstand attack packets that consume a tremendous amount of system resources. In all tests, a legitimate traffic degradation of 3% was allowed.

Performance Under SYN Flood Attack

The test results reflect the capacity of the tested products in dealing with SYN attacks while maintaining throughput of legitimate traffic with no more than 3% degradation.

This test utilized two tools, one that injects the SYN attack traffic while the other transmits legitimate traffic.

Radware's AppDirector handled up to 530,180 SYN attack packets while F5's BIG-IP tested units could only handle up to 317,580 SYN attack packets before legitimate traffic was degraded by more than the allowable 3%.

Performance Under ICMP Flood Attack

In this test, an ICMP flood attack was initiated against the tested product together with legitimate traffic, and the number of ICMP packets were measured until a drop of 3% in the legitimate traffic was reached.

Radware's AppDirector handled up to 968,993 ICMP packets in contrast to F5's BIG-IP that could handle only an average of 558,037 ICMP packets.

The results demonstrate that AppDirector 4008 could handle over 73% more ICMP flood packets while maintaining 1 Gbps of legitimate traffic.

Test Setup & Methodology

The test bed for all products was identical and composed of two Spirent Avalanche 2700 pairs, connected to a Cisco Catalyst 3560-G48 using copper cables. The DUT was connected to the same Cisco switch. During the audit, the Avalanche Commander 7.51 was configured using a SimUser load profile. See Figure 13.

Tolly Group engineers used four Avalanche pairs to ensure the test bed devices would not serve as a performance bottleneck.

With this configuration, engineers generated around 280,000 cps, which was significantly more than the DUT's capabilities. For the audit, engineers used a CPS load profile.

For Layer 7 performance, the platforms were tested with a single HTTP request, Tolly Group engineers used a Spirent Communication Avalanche 2700 to simulate the client side and a Reflector 2700 to simulate the server side. Engineers configured the Avalanche tool so each client initiated one GET request for one HTTP transaction per connection test and 10 GET requests for 10 HTTP transaction per connection test.

Note that the "Transaction Profile" parameter defined the size of the object that was returned from the Reflector. Data compression, data caching, Direct Server Return and URL filters were all disabled.

The Avalanche load profile was configured for four phases:

- Delay
- Ramp Up



The test methodology used for this report relies upon test procedures, metrics and documentation practices as defined by Tolly Common Test Plan #1077 Application Switch Performance.

To learn more about Tolly Common Test Plans, go to:

<http://www.CommonTestPlan.org>

- Steady State, and
- Ramp Down

The role of phase 0 and 1 was to allow the DUT time to recognize all of the servers. The Steady State phase used 300 seconds on all tests. The final results represent an average of the steady state number yielded.

For the security test, engineers used SmartBits to inject the SYN and ICMP attack packets, and to generate legitimate traffic engineers used an Avalanche 2700.

The objective of the test was to measure the maximum SYN/ICMP attack traffic that a DUT could block without affecting the legitimate traffic.

First engineers initiated the legitimate traffic using the Web Avalanche and once the device reached a steady state, engineers injected attack packets.

During steady state, engineers determined that the devices tested were able to sustain 1 Gbps of legitimate traffic while blocking SYN/ICMP attack packets in the background.



About Tolly

The Tolly Group companies have been delivering world-class IT services for more than 20 years. Tolly is a leading global provider of third-party validation services for vendors of IT products, components and services.

You can reach the company via E-mail at sales@tolly.com, or via telephone at +1 561.391.5610.

Visit Tolly on the Internet at:
<http://www.tolly.com>

Competitive Interaction

Radware acquired the F5 Networks BIG-IP appliances via normal product distribution channels. The Tolly Group invited representatives from F5 Networks to participate in the testing as per The Tolly Group's Fair Testing Charter (See <http://www.tolly.com/FTC.aspx>). Representatives from F5 Networks declined to participate.



A certified F5 BIG-IP performance expert verified that the configurations for the BIG-IP appliances were optimized for each test.

For more information on the Tolly Fair Testing Charter, visit:

<http://www.tolly.com/FTC.aspx>

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