Benefits of SSL Acceleration and TCP Connection Offload Using the Cisco Application Control Engine Module

The unique application acceleration capabilities of the Cisco® Application Control Engine (ACE) Module allow enterprises and service providers to optimize their existing data center infrastructure by: accelerating and scaling application deployments, reducing costs in the data center, simplifying application delivery network architectures, and improving application performance for end users. Laboratory testing of the module yielded the following results:

- TCP Connection Offload:
  - A 30-fold reduction in established TCP connections on the Web server was achieved.
  - Improved memory usage increased server capacity by up to 17 times.
  - A 20-fold increase in the number of HTTP requests served per second was achieved.
  - With improved transaction processing, all connections were processed successfully.
  - End-user response time was improved as a result of the connection handling capabilities of the Cisco ACE Module.
- SSL Acceleration:
  - Offloading SSL processing onto the Cisco ACE Module reduced server CPU load by up to 70 percent.
  - The Cisco ACE Module reduced the memory usage on the server by up to 50 percent.

Audience

This document is intended as a technical reference for networking professionals who are familiar with content switching, network design, and facilitation of services, and are interested in better understanding the potential of the application acceleration and optimization feature set of the Cisco ACE Module.

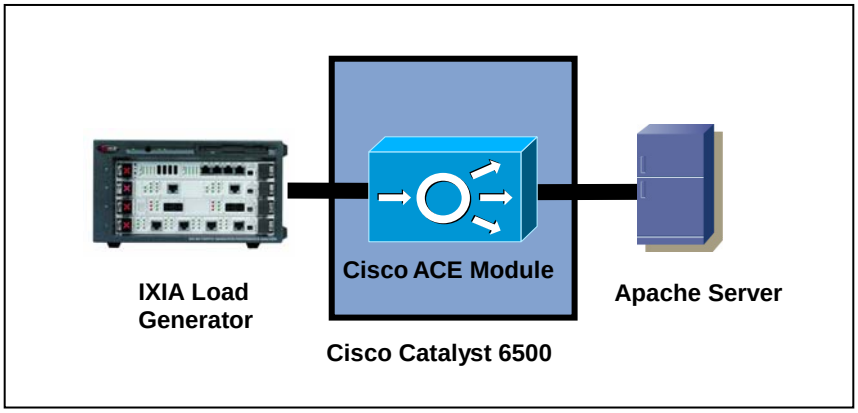
Overview

To meet the ever increasing demand for Web applications, network administrators face constant expansion of the physical server infrastructure. Common server tasks such as: SSL transaction processing and TCP connection handling, place significant strain on Web server resources limiting the overall capacity of an individual Web server. As a result, organizations deploying Web applications are challenged with ever increasing operating costs as they attempt to meet the operational requirements of acceptable site reliability and performance. The Cisco ACE product line offers impressive acceleration and optimization benefits to increase existing site capacity by offloading resource-intensive tasks from an individual server. As a result, existing application infrastructures can scale far beyond their original designed capacity. Through advanced offloading techniques such as SSL Acceleration and TCP Connection Reuse, the Cisco ACE Module reduces the cost and size of typical Web application infrastructure while providing improved application availability and performance.

Test Bed Description

In this test, a single Linux Web server installed with an Apache Web server was connected by Gigabit Ethernet to a Cisco Catalyst® 6500 chassis and placed into the server VLAN. To simulate client traffic, four ports of an IXIA 400T chassis were connected by Gigabit Ethernet to the Cisco Catalyst 6500 chassis and put into the client VLAN. The Apache server was fronted by the Cisco ACE Module by using a virtual IP (VIP) address configured on the module that load balanced to the server as a single real server in the server farm. To demonstrate the improvement in server capacity, the tests were completed with and without the Cisco ACE Module front-ending the server (Figure 1).

Figure 1. Test Setup



The specific hardware and software versions used for this test are provided in Table 1:

Table 1. Testing Specifics

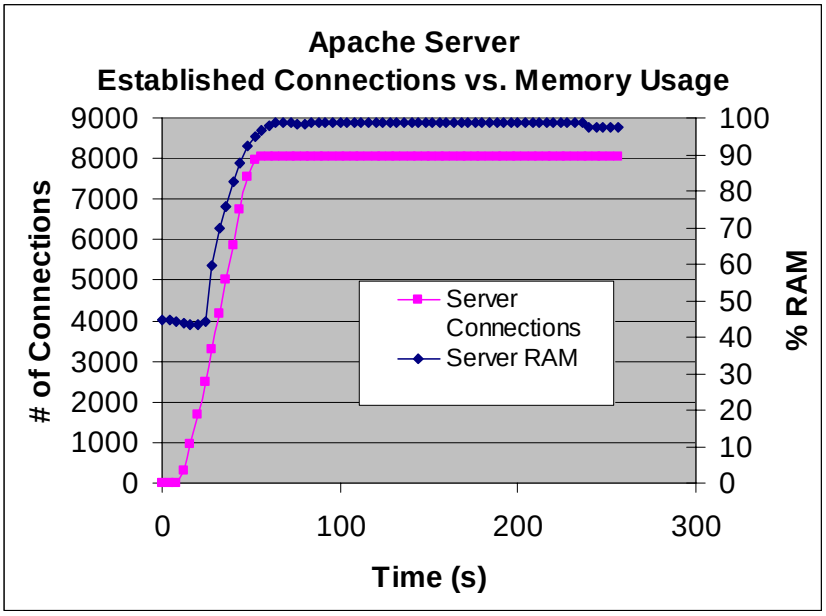
Component	Version

Server Hardware	Two dual-core 2.3-GHz Intel Xenon; 4-GB RAM; and 1-Gbps network interface card (NIC)
Server Software	Linux Redhat Enterprise AS 4 (2.6.9-42.ELsmp) and Apache 2.0.52
Cisco ACE Module	Version 3.0(0)A1(4n).
IXIA	400T
IxLoad Software	3.20.38.96

Server Benchmark

A test was conducted directly on the Apache server to obtain baseline performance measurements in order to determine the performance limitations of an individual Apache server. To stress the memory usage of the Apache server, the IXIA was configured to send an increasing amount of long-lived HTTP 1.1 client connections with a very low rate of requests per connection. This connection profile simulates a very slow client connecting to the server and represents a particularly difficult challenge for the server to manage. The server performance is bounded by both the availability of spare CPU cycles and the scarcity of free RAM used to process incoming client connections. As the load generator increased the number of incoming connections, RAM usage reached 100 percent on the server. A maximum of 8000 concurrent TCP connections was reached, as shown by the blue line in Figure 2. The server could not open any new TCP connections without sacrificing memory for critical system resources. Attempts to exceed this memory threshold resulted in the server becoming unstable and crashing. This memory bottleneck defines the upper bound of server capacity in terms of the maximum number of TCP connections that can be achieved.

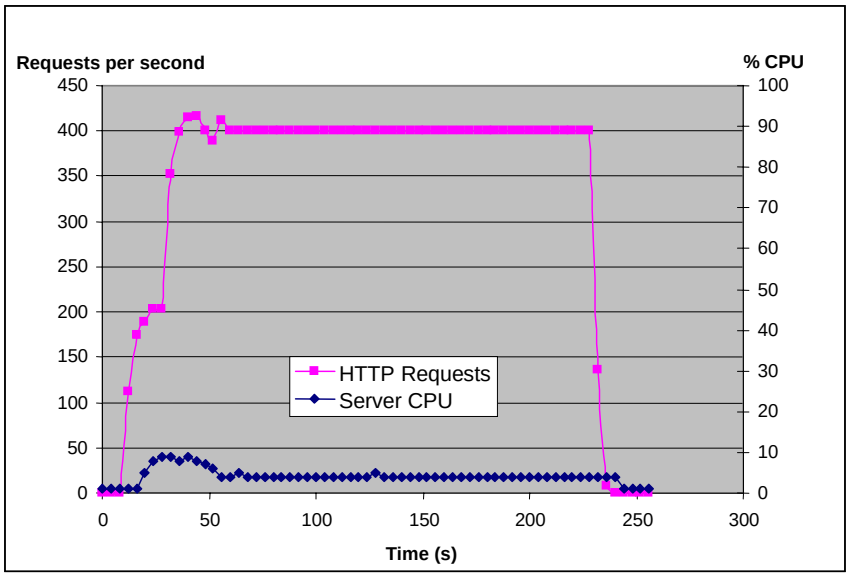
Figure 2. Maximum Established Connection Capacity of Apache



Because IXIA is configured to send a low HTTP request rate per established client connection, the server is forced to wait for HTTP requests to arrive on the open TCP connections. The relatively idle nature of the Apache server processes, servicing client connections, kept the server CPU usage to a minimum. IXIA peaked at a request rate of approximately 400 HTTP 1.1 requests per second. The CPU usage on the Web never exceeded 10 percent, as shown by the blue line in Figure 3. Although the CPU usage was low and more HTTP requests could have been processed,

the induced memory bottleneck prevented the server from taking advantage of available CPU cycles.

Figure 3. Limited Request Processing of Apache Server

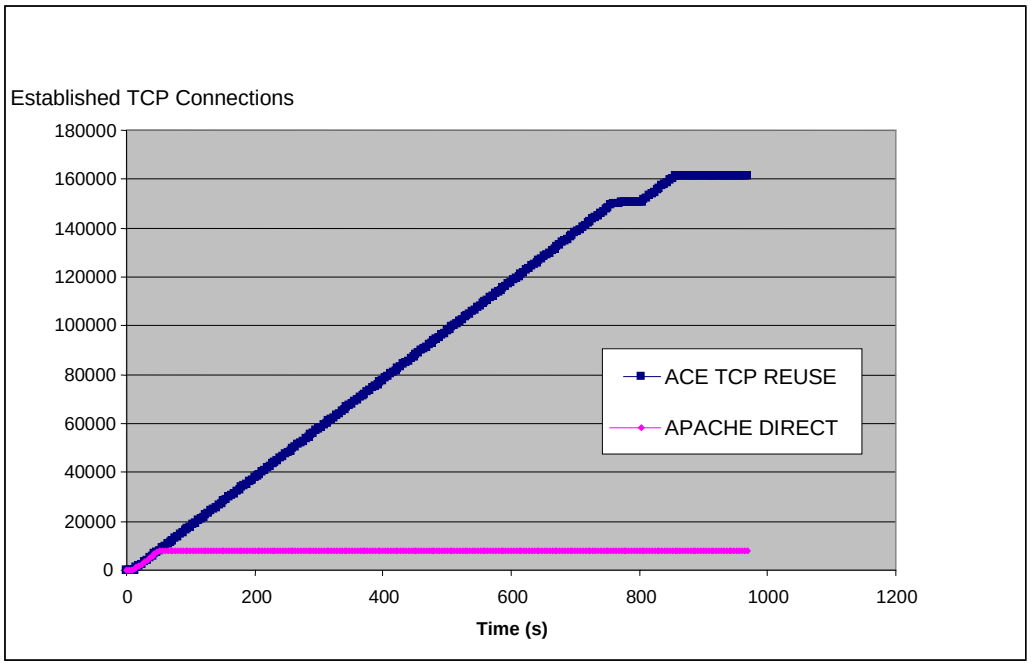


Cisco ACE TCP Connection Reuse

The same server benchmark test was completed with the Cisco ACE Module front-ending the Apache server to demonstrate the improvement in server capacity. The TCP Connection Reuse feature was enabled on the Cisco ACE Module to offload TCP connections from the Web server and traffic was sent by IXIA to the server VIP configured on the Cisco ACE Module, producing the results shown in Figure 4.

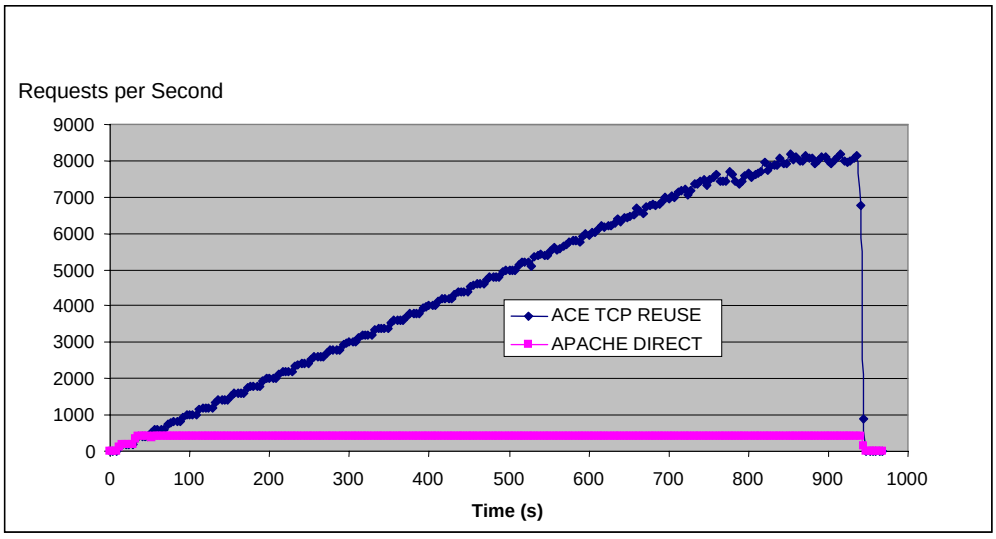
By allowing Cisco ACE to handle the incoming connections, the IXIA reached a maximum of 160,000 established TCP connections to the ACE module (Figure 4, blue line), whereas only 5,000 established connections were opened to the Apache server (Figure 4, pink line). A connection offload ratio of 32 to 1 was achieved using the TCP Connection Reuse feature of the Cisco ACE Module. The 30-fold increase in the number of connections offloaded by the Cisco ACE Module demonstrates that even under these formidable conditions, the server can process a significant amount of additional traffic load without a single connection failure. The improvement in server capacity results in a reduction of real servers per server farm necessary to sustain a given traffic profile. In addition, the cost associated with operating the application can be greatly reduced by reducing the number of real servers required per application.

Figure 4. Server Capacity Improvement: 17-Fold Improvement for Established TCP Connections



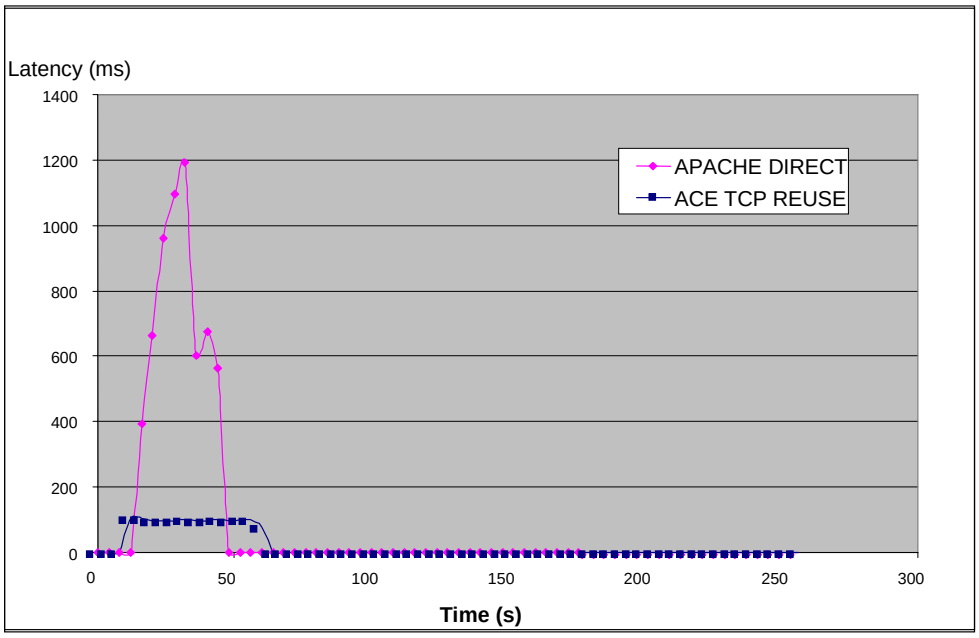
The improved server capacity in terms of established TCP connections also correlates with an increase in the number of HTTP requests served by the Apache server. With the TCP Connection Reuse feature enabled, the Cisco ACE Module was able to send a maximum of 8,000 HTTP 1.1 requests per second to the single Apache server. At the maximum HTTP transaction rate, server RAM and CPU usage both peaked at roughly 80 percent, demonstrating that the Cisco ACE Module can increase the ability of a server to process HTTP transactions by a factor of 20. Additionally, the improved performance is achieved while still allowing 20 percent of remaining server resources to be kept in reserve. Enabling TCP Connection Reuse increases the efficiency of server RAM usage, reducing data center cost while ensuring the application networking services can gracefully handle events such as traffic spikes and “flash-crowds” (Figure 5).

Figure 5. Server Capacity Improvement: 20-Fold Improvement in HTTP Requests per Second



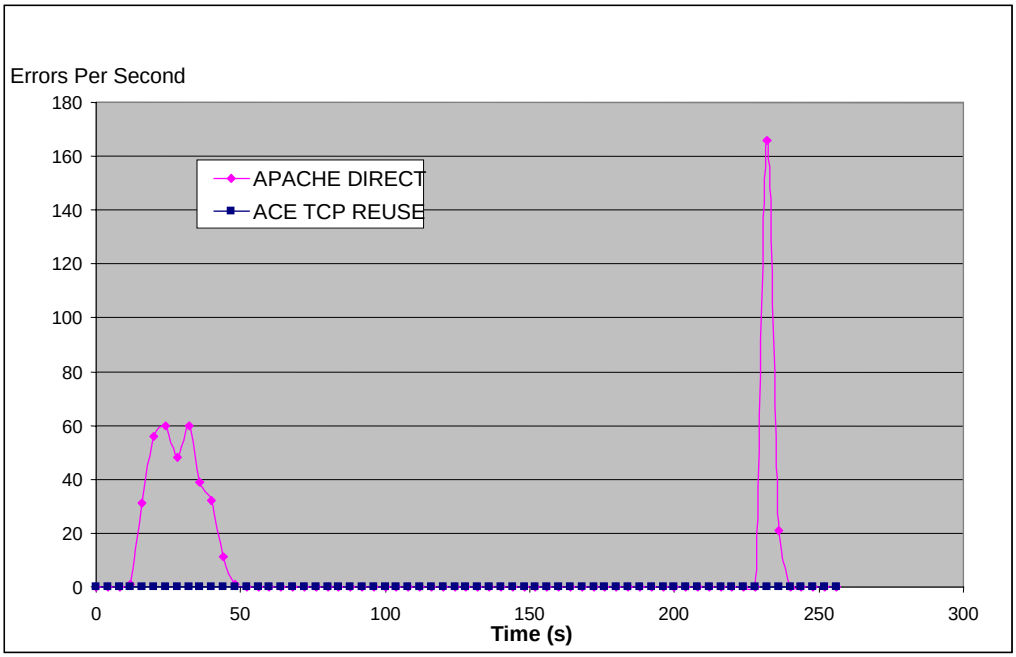
An additional benefit provided by the Cisco ACE Module is the reduction of both connection latency and connection error rates. The pink line in Figure 6 represents the inefficiency of the Apache Web server to create new TCP connections under peak traffic load. The blue line in the figure illustrates how the Cisco ACE Module improves application performance by establishing new incoming TCP connections up to 12 times faster than the Apache server.

Figure 6. Improved Connection Creation Latency: Up to 12 Times Faster



As the number of new users simulated by IXIA increases, the Apache connection latency spikes to more than 1 second to establish a TCP connection. To contrast this result with the Cisco ACE Module in the path, the connection latency does not exceed 100 ms -- and there are no connection errors (Figure 7, blue line). The lower connection setup latency achieved with the Cisco ACE Module results in an overall improvement in application availability and response time for all users.

Figure 7. Elimination of Connection Errors



Many important conclusions can be drawn from these results:

- By pooling TCP connections, the Cisco ACE Module reduced connections established with the Web server at a ratio of 32:1.
- TCP Connection Reuse technology increased the number of connections a single Web server could accommodate, thereby increasing the server capacity by up to 17 times.
- A 17-fold increase in established TCP connections was achieved by using a smaller fraction of the server memory pool (80 percent vs. 100 percent in the direct case), thereby freeing remaining server memory resources for other tasks such as content processing.
- At peak performance there were no transaction failures when user traffic flowed through the Cisco ACE Module. Attempting to gain absolute maximum performance from the Web server in baseline testing resulted in many unsuccessful transactions after the performance threshold was reached. The Cisco ACE Module increased the server capacity and also helped ensure that all transactions were served successfully.
- The Cisco ACE Module eliminated the server connection processing bottleneck, allowing the Web server to achieve its true full capacity in terms of both RAM and CPU usage. With the Cisco ACE Module the Web server processed significantly more transactions while maintaining a modest reserve of system resources.
- End users' response time was improved as a result of the excellent connection handling capabilities of the Cisco ACE Module.

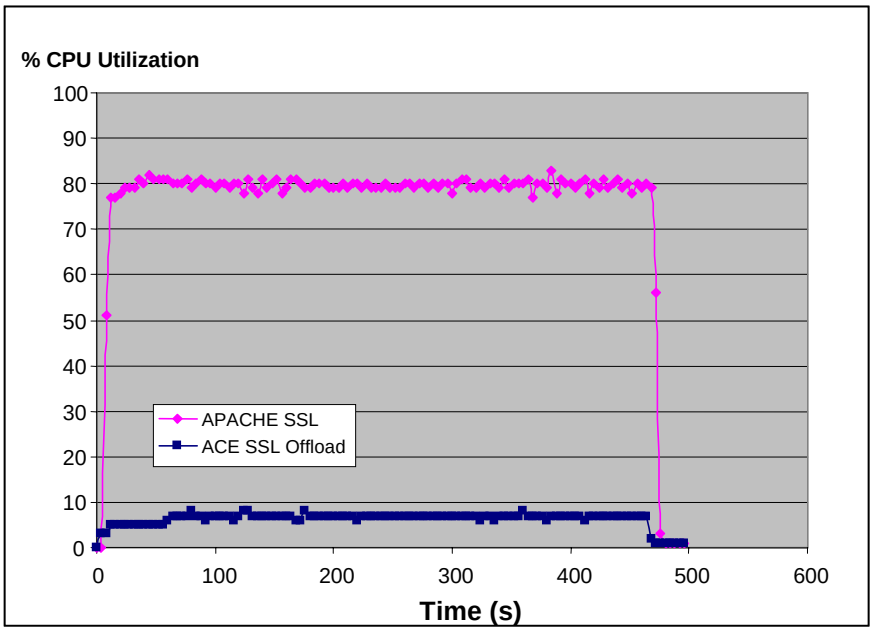
Cisco ACE SSL Acceleration

The SSL Acceleration technology offered by the Cisco ACE Module effectively offloads CPU-intensive processing from servers by migrating SSL decryption from the application server onto a high-performance device designed to more effectively process SSL transactions. The resulting reduction in CPU usage on the Web server allows it to reliably process greater rates of session setups and traffic throughput, translating into a reduction in the number of servers required to meet today's level of secure application traffic.

To demonstrate the advantages of the Cisco ACE Module SSL Acceleration technology, the system resources of an Apache server were measured with and without the use of SSL termination by the Cisco ACE Module. The IXIA was used to simulate up to 1000 simultaneous users, each making a single HTTP 1.0 request per second. Removing the burden of SSL transaction

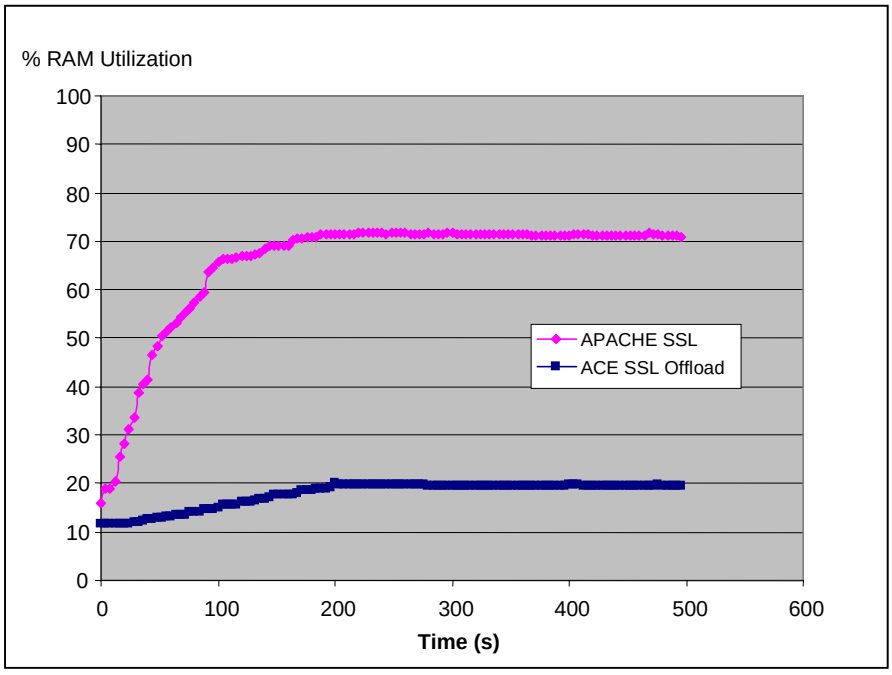
processing from the Apache server resulted in a 70-percent reduction in CPU usage (Figure 8).

Figure 8. Reduction in Server CPU Usage: 70 Percent



In addition to the reduction in CPU usage, there is also a significant reduction in memory usage. Figure 9 shows that with Cisco ACE offloading SSL processing, the Apache server used 50-percent less memory to process the same number of HTTP transactions per second.

Figure 9. Reduced RAM Usage: 50 Percent



The following immediate conclusions can be drawn from these results:

- Offloading SSL processing onto the Cisco ACE Module reduced server CPU load by up to 70 percent, allowing for the reduced size and reduced cost associated with building and maintaining a large number of SSL server farms.
- The Cisco ACE Module reduced the memory usage on the server by up to 50 percent, improving the server capacity by allowing even greater numbers of connections to be processed.
- The need for SSL processing on the Web servers was removed.
- Consolidation of SSL certificates on the Cisco ACE Module reduced the cost associated with SSL certificate creation of a Web server farm. The Cisco ACE Module also allowed for centralized management of SSL certificates.
- With reduced cost associated with SSL processing, organizations can more easily afford to migrate applications to secure SSL communication.

CONCLUSION

The Cisco ACE Module provides scalable, reliable, and cost-effective application delivery services in the data center. Enterprises and service providers alike can reap significant cost reduction and application deployment acceleration benefits with the Cisco ACE Module.

FOR MORE INFORMATION

For more information about the Cisco ACE Module, visit http://www.cisco.com/go/ace or contact your local account representative.

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

Asia Pacific Headquarters
Cisco Systems, Inc.
168 Robinson Road
#28-01 Capital Tower
Singapore 068912
www.cisco.com
Tel: +65 6317 7777
Fax: +65 6317 7799

Europe Headquarters
Cisco Systems International BV
Haarlerbergpark
Haarlerbergweg 13-19
1101 CH Amsterdam
The Netherlands
www-europe.cisco.com
Tel: +31 0 800 020 0791
Fax: +31 0 20 357 1100

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