Executive Summary

Today's blade server systems provide customers with platforms that can host many physical servers and potentially a hundred or more virtual servers. It is essential that these systems provide high-bandwidth connectivity in an any-to-any fashion across physical and virtual servers in order for customers to reap the benefits of blade-based virtualization and not encounter bandwidth-related application performance issues, particularly for I/O intensive applications such as ERP, CRM or database servers.

Tests show that Cisco's Unified Computing System (UCS) architecture, that requires 10Gbps switch ports to provide blade-to-blade connectivity, restricts aggregate throughput of a single fabric extender to ~40Gbps (80 Gbps for eight servers with two FEX modules) when servers are placed optimally to avoid bandwidth contention. The HP Virtual Connect Flex-10 architecture has no such restrictions. Furthermore, tests show that as additional traffic streams are sent among the servers, contention for bandwidth causes Cisco's aggregate throughput to drop by almost 10Gbps where HP's aggregate throughput scales linearly upward. Cisco's bandwidth contention issues can be problematic for customers wishing to leverage automated virtualization systems such as VMware's vMotion.

The Bottom Line

1. Test results show that server blades with HP Virtual Connect Flex-10 architecture deliver higher throughput than Cisco UCS server blades
2. HP Virtual Connect Flex-10 can be configured to provide any server with up to full 10Gbps of dedicated throughput
3. HP Virtual Connect Flex-10 delivers non-blocking intra-chassis throughput
4. Throughput degradation on the Cisco UCS caused by bandwidth contention is a cause of concern for customers considering the use of UCS in a virtual server environment
**Introduction**

Testing focused on benchmarking the scalability of network input/output of both real and virtual servers running within a single chassis enclosure.

HP and Cisco take very different approaches to providing intra-chassis, blade-to-blade communication.

HP’s Virtual Connect is implemented as a fabric-based solution. This approach allows all communications among blades in a single chassis to take place without requiring an external switch.

Cisco’s blades communicate by going through an external fabric interconnect (switch) even when the blades reside in the same enclosure. Tests reveal significant performance limitations to Cisco’s approach.

**Summary of Findings**

Tests of intra-chassis network performance show that Cisco’s UCS requires specific server placement (called “pinning” by Cisco) to achieve optimal performance. Furthermore, once contention for bandwidth is introduced, the aggregate throughput falls off significantly as more streams are added.

Cisco acknowledges in its UCS Manager GUI Configuration Guide 1.x (OL-20056-0) that the user cannot change which servers are pinned to which uplink, it is fixed. With one uplink wired, all eight UCS blades share this single link. Even in the best case, with four uplinks, each link is shared by two server slots. When four servers in slots that do not share uplinks communicate in pairs, bi-directional, aggregate throughput of 36.59 Gbps is achieved. This compares with 35.83 Gbps with HP. See Figure 1.

When another pair of blades is added to the test requesting increments of 2Gbps of bandwidth, HP’s throughput increases linearly to 53.65 Gbps to handle all of the additional server traffic. Cisco’s throughput, however, drops significantly.

Not only can Cisco not exceed the 40 Gbps limit of the fabric extender connections, the contention for bandwidth degrades the overall aggregate throughput of all systems. The interim data points in Figures 1 and 5 illustrate this clearly.

By the time the test reaches its maximum load, Cisco’s aggregate system throughput is about 10 Gbps lower than at the beginning of the test. In fact the difference between...
the HP and Cisco throughput at the end of the test is 26.29 Gbps, just under Cisco's aggregate throughput. Thus, under this load, HP delivers throughput twice as much as Cisco.

Virtual Server Throughput

Engineers ran a similar test this time using eight Linux virtual machines running on each blade under VMware and just a single pair of server blades for each test configuration. As before, bi-directional traffic streams were generated.

HP delivered 16.42 Gbps of aggregate system throughput regardless of which slots the servers occupied in the chassis. See Figures 2 and 6.

Under the best-case scenario for Cisco, when the two Cisco blades were placed into slots that did not share an uplink, Cisco results were 16.70 Gbps. When, however, the blades were placed in slots that shared an uplink, aggregate throughput dropped by nearly half to 9.10 Gbps.

The drop in Cisco's throughput is caused by both systems needing to send all network traffic to/from each other through a single, shared 10Gbps full-duplex connection.

Since the user cannot modify how the server traffic flows to the UCS uplink ports, the degradation on the Cisco UCS caused by bandwidth contention can be a cause of concern for customers planning to use UCS as a platform for virtual computing. Virtualization management platforms, such as VMware vMotion, automatically migrate virtual servers based on load. With Cisco, a migration to a different blade could result in degraded application performance for the migrated server as well as servers already running on that blade.

Test Bed Setup

The HP BladeSystem c7000 was equipped with six ProLiant BL460c G6 servers and an HP Virtual Connect Flex-10 10Gb Ethernet

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP Virtual Connect Flex-10 10Gb Ethernet Module</td>
<td>1</td>
<td>Virtual Connect FW 2.31</td>
</tr>
<tr>
<td>HP BladeSystem c7000 Enclosure</td>
<td>1</td>
<td>HP ProLiant On Board Administrator 2.606f, ROM 124 2009.10.01, FW was flashed with the 8.70 Firmware CD</td>
</tr>
<tr>
<td>HP ProLiant BL460c G6 Blade Server</td>
<td>6</td>
<td>Each server was outfitted with two Intel X5570 processors, two 73GB HDD, SAS, 15,000RPM, 24GB RAM(6x4GB 2Rx4 PC2-10600R) FW 8.70</td>
</tr>
</tbody>
</table>

Source: Tolly, February 2010
Module, functionally equivalent to the Cisco UCS 5100 Blade Server Chassis with six B200 servers, two UCS 2104 Fabric Extender modules, and one UCS 6120XP Fabric Interconnect switch. (Only one fabric extender module was used.) Each solution was configured with the latest publicly available updates as of February 8th, 2010.

All Cisco and HP blade servers were equipped with identical processor and memory configurations. The processors ran at 2.93GHz and the RAM at 1333MHz. See Figures 3 and 4 for additional details.

Each Cisco blade was outfitted with a Cisco converged network adapter. Each HP blade was outfitted with a 10GbE interface.

**Test Setup & Methodology**

**Aggregate Throughput Test**

System defaults were used except that Cisco QoS was configured for “Best Effort Priority”. Without this setting, Cisco’s performance was degraded further. For HP virtual server tests, the Broadcom NIC driver was set to NETQ=8. For the Aggregate Bidirectional Network Throughput Scalability test, engineers configured bare-bones installations of Red Hat Enterprise Linux 5 u4x64, running only Ixia IxChariot Endpoint 7.0 on each of the blade servers in each vendor’s chassis. Engineers then defined two server pairs, between which, traffic was generated at the highest possible levels. (Referencing the Cisco architecture, traffic was generated between blades 3 & 5, and between blades 4 & 6) Once the baseline for each vendor was recorded, engineers

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**HP Virtual Connect Technology**

HP Virtual Connect is a server edge networking technology for HP BladeSystem that enables server LAN and SAN connections to be pre-provisioned and virtualized. Moving workloads and performing server maintenance tasks can be done without the need to coordinate with network and/or storage administrators, resulting in greater flexibility and speed of execution.

Virtual Connect Flex-10 technology, which is built into BladeSystem servers, reduces infrastructure costs by increasing the number of NICs supported without the need to add extra NICs or managed switches. The HP Virtual Connect Flex-10 10Gb Ethernet module dramatically reduces the number of cables required while managing the server FlexNIC connections to the data center network. The module recognizes and manages each FlexNIC as part of a server profile. Each Flex-10 NIC provides up to four FlexNIC connections, with support for a total of 24 NIC connections per HP half-height server blade.

In addition to lower infrastructure costs, HP Flex-10 delivers more server network bandwidth while the speed of each NIC can be adapted to the demands of the application using it. The bandwidth of each connection can be fine-tuned and adjusted in 100Mb increments up to 10Gb, as workload demands change. With this flexibility customers are no longer forced to over-provision their networks or under-provision their server connections due to fixed NIC speeds.

Source: HP

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**Server-to-Server, Aggregate Bi-directional Network Throughput Scalability**

Six Server Blades Total, Baseline of Two Server Pairs

(as reported by Ixia IxChariot version 7.0)

<table>
<thead>
<tr>
<th>Solution (Difference between Cisco and HP Throughput)</th>
<th>Baseline</th>
<th>Additional Requested Server Traffic in Gbps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Cisco UCS</td>
<td>36.59</td>
<td>34.82</td>
</tr>
<tr>
<td>HP BladeSystem</td>
<td>35.83</td>
<td>37.96</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.76</td>
<td>3.14</td>
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</tbody>
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Note: These are the data points illustrated graphically in Figure 1.

Source: Tolly, February 2010

Figure 5
introduced levels of bidirectional traffic between the two remaining blades (7 & 8, on Figure 6). Engineers witnessed the overall aggregate throughput steadily decline on the UCS, due to the limitation of each blade’s bandwidth to fairly saturate the links to the Fabric Interconnect Switch, while the overall throughput of the HP BladeSystem increased at the rate additional traffic was introduced.

Virtual Server Throughput Test
For the vMotion throughput test, engineers configured 8 virtual machines on two separate blades, each of which was given 2GB RAM, 1 vCPU, running Linux RHEL5u4x64 on VMware ESX 4.0.0.208267. The only software installed on the host OS was VMware tools, and Ixia IxChariot Endpoint version 7.0.

Engineers configured IxChariot to pair VMs across blades, and introduced several streams of bidirectional traffic between the systems by means of the built-in IxChariot script for throughput testing. Cisco's performance was dependent on the physical location of the VMs within the chassis.

Competitive Interaction
The Tolly Group invited representatives from Cisco Systems to participate in the testing as per The Tolly Group's Fair Testing Charter.

Representatives from Cisco declined the invitation to participate.

For more information on the Tolly Fair Testing Charter, visit: http://www.tolly.com/FTC.aspx

Cisco UCS Slot-to-Uplink Mapping
Test Engineer's Observations
This diagram represents the Cisco 5108 Blade Server Chassis. Each number represents a slot, each letter an uplink. Because the fabric of the UCS is non-routing, each packet originating and terminating on the blades must leave the chassis and transit the Fabric Interconnect Switch via the 4x 10GE links and be routed back to the chassis through a 10GbE link.

The color-coded slots represent the blades that share (i.e., are “pinned” to) the same physical 10GbE link. During testing, engineers ran the performance test, first across blades 3 & 5, yielding 16.7 Gbps of aggregate bidirectional throughput, since the blades were not contending for bandwidth on the same physical link. Though when engineers migrated the VMs to reside instead on blades 3 & 7, running the same test resulted in an aggregate bidirectional throughput of 9.1Gbps, since the effective link capacity of both of the blades residing on that 10GbE link has been reduced to 5Gbps because of contention, while the other three links to the Fabric Interconnect Switch remained idle and unused.
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Visit Tolly on the Internet at: http://www.tolly.com

Test Equipment Summary

The Tolly Group gratefully acknowledges the providers of test equipment/software used in this project.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Product</th>
<th>Web</th>
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<td>Ixia</td>
<td>IxChariot version 7.0</td>
<td><a href="http://www.ixiacom.com/">http://www.ixiacom.com/</a></td>
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