White Paper

Broadcom’s Integrated Solutions For Cloud Scale Computing with Windows Server 2012

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Contents

Bringing Cloud-Scale Architectures to the Masses

Cloud Scale Requirements

Broadcom Solutions for Windows 2012

Enhanced Performance

Moving Forward

The Bigger Truth

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Bringing Cloud-Scale Architectures to the Masses

Pioneers in cloud computing like Google and Amazon Web services have designed and built cloud scale architectures. However, because they couldn’t find products and solutions from existing vendors to serve their needs, they had to build their own. While this ensured massive scalability, multi-tenancy, and tightly integrated solutions running over readily accessible infrastructure, it has not come without a cost. By creating their own IT environment, they also must maintain a large staff of developers to build and support these solutions for the business.

In contrast, most enterprises do not staff to custom build an IT environment. They need integrated solutions from existing technology partners. Today, many mainstream enterprise data centers are starting to look a lot more like those of service providers, as illustrated by ESG research. For example, increased use of server virtualization has been either the number one IT priority reported by respondents, or tied for number one, for the last three years in ESG’s annual IT spending survey (see Figure 1).\(^1\)

As these virtualized environments mature, organizations realize that much more can be accomplished than just consolidating infrastructure, and when properly deployed, they can lead to much higher levels of IT agility for the business. As a result of IT needing to be more responsive to the business, ESG research indicates that more enterprises are looking to build out private cloud environments. In fact, in the 2012 spending intentions survey, it became a top ten priority.

**Figure 1. Top IT Priorities for 2012**

<table>
<thead>
<tr>
<th>Priority</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve data backup and recovery</td>
<td>30%</td>
</tr>
<tr>
<td>Increased use of server virtualization</td>
<td>30%</td>
</tr>
<tr>
<td>Major application deployments or upgrades</td>
<td>29%</td>
</tr>
<tr>
<td>Manage data growth</td>
<td>27%</td>
</tr>
<tr>
<td>Information security initiatives</td>
<td>27%</td>
</tr>
<tr>
<td>Business continuity/disaster recovery programs</td>
<td>25%</td>
</tr>
<tr>
<td>Data center consolidation</td>
<td>24%</td>
</tr>
<tr>
<td>Desktop virtualization</td>
<td>23%</td>
</tr>
<tr>
<td>Mobile workforce enablement</td>
<td>22%</td>
</tr>
<tr>
<td>Deploying a &quot;private cloud&quot; infrastructure</td>
<td>22%</td>
</tr>
</tbody>
</table>

*Source: Enterprise Strategy Group, 2012.*

In addition to data center consolidation ranking as a top ten priority in the annual IT spending report, ESG also conducted a data center networking trends survey of North American enterprises in which respondents indicated that 63% had either just completed or were in the middle of a data center consolidation project.\(^2\) Even more telling

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was the fact that almost half of those respondents (48%) stated that they were building out multi-tenant environments.

The greater the level of consolidation, convergence, and multi-tenancy, the harder it will be to manage and operate these at cloud scale. Furthermore, it will become more important for trusted vendors to step up and deliver tightly integrated solutions to help them build and manage these environments, and extract the most value possible from them.

Fortunately, technology vendors have been developing new operating systems, processors, server architectures, and server I/O technologies to better enable the enterprise to build out high performance cloud scale architectures. One such example can be seen with Dell and HP working closely with Microsoft (O/S), Intel (processor), and Broadcom (server I/O) to ensure balanced and optimized performance for cloud scale environments that take advantage of Windows Server 2012, Intel Xeon E5 (“Romley”), and Broadcom NetXtreme family technology. Although each of the parts can deliver value on its own, the overall value to the enterprise is amplified when the solutions are tightly integrated.

This paper will focus on the improvements and tight integration Broadcom has developed with tier-1 Server vendors (Dell, HP, IBM, and others) and Microsoft to help enterprise and emerging service or cloud providers create cloud scale environments.

**Cloud Scale Requirements**

Clearly, data centers are growing much larger and more complex in order to support the larger and more complex environments organizations require. They need to have the following capabilities.

- **Support for multi-tenancy** – Every service and cloud provider with external customers will need a multi-tenant environment, and now more and more enterprises are looking to deploy multi-tenant environments to support different business units and provide secure links. Technology now exists at the I/O level to virtualize data paths for better isolation, quality of service, and security.

- **Better management** – It is clear that with the increased scale, organizations need to find ways to simplify and automate management—in fact one of the biggest challenges listed in our data center networking report was “too many manual processes.” Organizations need to find management solutions that are simple and intuitive, so that certifications are not required. Also, the management solutions need to ensure that the environment is optimized for performance yet conscious of power consumption. This is especially important in many power constrained geographies. Better management also requires the ability to remediate problems faster. Deploying staff to comb through remote data centers is too time consuming, and error prone. Solutions should be enabled for remote connection.

- **Tight integration** – Cloud environments are all about agility and performance—not individual performance, but end-to-end performance. Because an environment will only be as strong as its weakest link, it is important when building out cloud environments that the complete solutions have been tested and verified to work together under load. The other benefit of tight integration is that support for the implemented devices is already preloaded, and doesn’t require any additional actions to go online and download drivers.

- **High bandwidth** – With all the increased use of virtualization technology, organizations are creating higher levels of VM density—that is, the number of VMs per physical host. ESG research indicates that organizations are averaging between five and ten VMs today, but heading to 25 or more over the next 24 months, and will need to have high bandwidth solutions deployed. Fortunately, ESG research also highlights the fact that almost half (47%) of respondents are actively transitioning from 1GbE-to-10GbE (see Figure 2).³

³ Source, Ibid.
Quality of service – Because these environments will inevitably host multiple different workloads, it will be imperative to ensure that the mission-critical applications can get priority service levels. This will require the network to understand and be aware of the applications that reside on the virtual machines (VMs). In addition, the CPU should be dedicated to handling more VMs and not to transport protocol offload processes. Organizations need to find network or I/O solutions capable of handling those tasks.

Multi-protocol support – Network convergence can help to dramatically reduce costs and complexity in the data center, and organizations can better match the needs of the application to the protocol delivering it, regardless of whether it is FC, FCoE, ISCSI etc.

Broadcom Solutions for Windows 2012

Broadcom understands the importance of having tightly integrated solutions to enable highly virtualized and cloud environments. It has worked with industry leaders such as Dell, HP, IBM, and others on new server architectures (Romley), and to ensure its customers can extract the full value of new operating systems, Broadcom also worked closely with Microsoft to tightly integrate its converged network adapter technology into Microsoft’s Windows Server 2012.
To better enable scalable multi-tenant cloud environments, Broadcom has introduced several new integration points with Microsoft Windows Server 2012 when deployed on tier-1 servers. The integration points include:

- **Single Root I/O Virtualization (SR-IOV)** – This technology enables Broadcom server I/O cards to support highly virtualized environments by making it appear as though there are up to 128 dedicated interfaces available to the operating system residing on a virtual machine, in this case Windows Server 2012. This technology enables each OS to have its own logical adapter and provides higher levels of performance, flexibility, and scalability. More importantly for cloud and multi-tenant environments, it provides isolation and security. For organizations expanding their virtualization footprint or building out cloud environments, this will be very compelling technology.

- **Quality of Service (QoS) leveraging Data Center Bridging (DCB)** – In these highly virtualized and cloud environments with increasing VM densities and varying workloads, it will be imperative to establish some form of quality of service to ensure that mission-critical applications are given priority. Broadcom and Microsoft have accomplished this by leveraging DCB to establish multiple classes of QoS which can be integrated with the Windows stack to provide end-to-end QoS. The QoS functions can apply not only to virtualized environments, but also to differentiate services on converged networks (FCoE and iSCSI) and multi-tenant environments.

- **Receive Side Coalescing (RSC)** – Windows Server 2012 can leverage Broadcom’s RSC capable NICs to help reduce the I/O traffic processing overhead on the server, especially for a large number of small packets. Broadcom network adapters leverage hardware offloads to perform this stateless RSC offload. Essentially, RSC-enabled adapters work with Windows 2012 to reduce the overhead associated with data transmission.
This process will help to dramatically reduce the amount of CPU power required to process each of these packets. This will free up the CPU to host additional VMs.

- **iSCSI and FCoE Storage Offloads** – Broadcom Controllers provide a full suite of storage offloads with Windows Server 2012, enhancing overall performance and reducing total cost of deployment. Broadcom Ethernet controllers have full support of iSCSI and FCoE offload storage protocols, and Broadcom claims they are capable of delivering up to 1.5 million iSCSI input/output operations per second (IOPS), or 2.5 million FCoE IOPS with superior CPU efficiency.
  
  o **iSCSI & FCoE Driver Integration (Inbox)** – To enable rapid installation and accelerate time to value, the Broadcom adapter drivers are preinstalled in Windows Server 2012. This integration will simplify set up times when deploying server infrastructure fitted with Broadcom adapters.

- **Dynamic Virtual Machine Queues (D-VMQ)** – In order to better take advantage of CPU resources and I/O virtualization, Microsoft introduced VMQ in 2008 R2, which allowed a VMQ capable adapter to statically assign a fixed number of I/O paths and processors to distribute a heavy workload. (Without this, a single CPU could easily become overwhelmed with a high volume of traffic.) In Windows 2012, Microsoft has advanced this capability to dynamically adapt network processes (queues) across as many CPUs as needed, and then return those resources to the pool when they are no longer required. As a result, organizations leveraging Broadcom’s D-VMQ capable adapters will be able to see increased network performance.

- **Consistent Device Naming** – The ability to simplify the naming convention will dramatically help administrators keep track of and manage their environments. Organizations will be able to save time and money by leveraging intuitively obvious and consistent device naming conventions, and eliminate the need to look up ports in a spreadsheet to determine their location or function.

- **Kernel Debugging over Network (KDNet)** – This allows organizations to troubleshoot the environment remotely instead of having to rely on slow serial cable connectivity, USBs requiring special hardware or lack of 1394 (Firewire) availability. As environments grow in scale, the ability to remotely access and troubleshoot a rapidly growing environment will greatly accelerate the time to repair.

- **Multiple KGROUPs** – A KGROUP is an arbitrary collection of 64 Processors. In Windows 2012, organizations will be able support multiple KGROUPS. This will serve to better enable cloud scale environments.

- **Wake packet detect** – This technology enables organizations to better handle power management offload. Enabled in the OS and network interface cards, organizations will be able to automatically power servers back on by detecting a “wake” packet. This allows organizations to conserve power in off hours and power back up to meet anticipated demand before it is actually needed, for example the start of a work day, etc.

In addition, to the new features listed above, Broadcom continues to offer the following key features:

  o **NIC Partitioning (NPAR)** – NPAR enables organizations to make better use of mixed workload and multi-tenant environments. This partitioning enables QoS to ensure that VMs hosting mission-critical applications always have sufficient throughput.

  o **Virtual Connect** – Broadcom supports HP’s Virtual Connect Flex-10 program at all levels including LAN-on-motherboard, mezzanine cards, and server adapter cards.

  o **Adapter Fabric Extender (AFEX)** – The Broadcom solutions support Cisco’s AFEX fabric virtualization program to the end point. This allows guest virtual machines the ability to connect with the fabric extension protocol.

  o **Receive Side Scaling (RSS)** – This technology distributes monitoring interruptions across multiple processors, reducing the burden on any one processor. High-end computers can leverage this technology to spread the load across logical processors.

  o **TCP/IP Offload Engine (TOE)** – Broadcom leverages a silicon chip approach to transfer any processing overhead from host CPU to a NetXtreme BCM57810S or BCM67800S 10GbE controller.
This enables the processor cores and memory resources to focus solely on obtaining higher throughput and I/Os per second, while reducing CPU utilization and power usage.

**Enhanced Performance**

By working closely with Microsoft, Broadcom was able to bring advanced technologies to enable greater inbox support and functionality for virtualization, networking, and storage. Broadcom claims these integrated solutions will be able to increase network throughput performance by as much as 77% and reduce CPU overhead by as much as 42%.

**Moving Forward**

Regardless of where your organization is on the path towards highly virtualized private clouds, it can leverage integrated solutions featuring Broadcom technology. Organizations often struggle to piece together best-of-breed technologies, and in most cases it takes a great deal of time and money to fully validate compatibility and architectural fit, so tightly integrated solutions can help to accelerate time to value.

- **Highly virtualized environments** – These are for those organizations still in the process of virtualizing their server environment. The ability to quickly turn up services with inbox drivers and leverage QoS to better handle multiple different workloads while increasing VM densities will help to guarantee service levels and technologies like SR-IOV, and will reassure application owners that the virtual I/O paths are isolated and secure.

- **Private clouds** – Organizations that have matured their virtualized server environments to more dynamic cloud environments will not only benefit from the features mentioned above, but also the Dynamic Virtual Machine Queues should prove to be highly valuable in environments that sustain rapid growth or periods of bursty performance. The ability to match compute-to-network traffic will help organizations to adjust on the fly, and enable the true promise of cloud computing.

- **Hybrid clouds** – ESG research indicates that organizations will not only take advantage of private clouds, as indicated on the top IT priority list, but will also leverage public clouds. In fact, when asked about areas of increased budget spend, respondents chose public cloud computing as their number one response, with 74% indicating that they would spend more this year. This opens up the possibility for organizations to leverage both private and public clouds in a hybrid environment. The best way to prepare for such an environment is to build out a robust private cloud.

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The Bigger Truth

Enterprise organizations are building out highly virtualized environments and evolving them into cloud computing environments. The data also indicates that as data center consolidation continues to be a top trend, enterprise data centers are beginning to look a lot more like service provider data centers. They are becoming multi-tenant and, due to all the consolidation, rapidly approaching massive or cloud scale.

Organizations looking to make the transition easier should look for vendors that have created tightly integrated solutions to help accelerate the transition into cloud models. By working together to validate and integrate technologies that enable better network isolation and security, it will be easier for organizations to create flexible and dynamic IT environments.

Broadcom, an industry leader in server I/O technology, has worked with Microsoft, Dell, HP, IBM, and others to ensure optimal performance and tightly integrated feature sets to help accelerate the transition to both highly virtualized and private clouds. The integration highlighted in this paper will help organizations to take advantage of Microsoft’s new operating system, Dell, HP, IBM, and other tier-1 server vendor’s advanced server architectures featuring Intel processors, and Broadcom’s NetXtreme converged adapters which support the latest I/O technology to enable multi-tenant cloud scale computing environments. While each of these vendors provides valuable technology, the ability to tightly integrate it ensures that the value exceeds the sum of the parts.