In this paper, Taneja Group presents an evaluation of the virtualization and cloud solution market for small and medium business (SMB) users (companies with less than 1000 employees). Our objective is to evaluate virtual infrastructure and management, end user computing, and cloud service provider solutions from leading vendors, to enable senior decision makers in SMB organizations to decide which vendors in the market offer the best virtualization and cloud solutions.

We evaluated four of the leading virtualization and cloud solution vendors and scored their offerings in two categories: virtualization and management, and end user computing. Next, we evaluated the three leading public cloud IaaS ecosystems, and scored the offerings of a representative service provider in each one. All vendors were required to have solutions in one or more categories that are expected to be generally available as of September 2012. To assess the competitive offerings, we looked at eight differentiating factors in each of the three categories, which we believe small and medium business customers should use to qualify virtualization and cloud solutions and services. As a final step, we reviewed the vendors’ solutions, services and overall cloud strategy, and – using the leading vendor as the baseline – explored how competitive solutions compare favorably and unfavorably against that vendor’s solutions.

**SMB Virtualization/Cloud Market: Ranking Solutions & Services (4 = Highest Score)**

<table>
<thead>
<tr>
<th>Roll-Up Scores</th>
<th>VMW</th>
<th>MSFT</th>
<th>CTXS</th>
<th>RHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtualization and Management</td>
<td>3.8</td>
<td>2.6</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>End User Computing</td>
<td>3.3</td>
<td>2.0</td>
<td>2.8</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roll-Up Scores</th>
<th>VMW</th>
<th>OpenStack</th>
<th>AMZN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Cloud IaaS Ecosystem</td>
<td>3.6</td>
<td>2.5</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Legend: VMW=VMware, MSFT=Microsoft, CTXS=Citrix, RHT=Red Hat, AMZN= Amazon

To assess each vendor’s virtualization and management offerings, we evaluated factors such as virtualization platform, service-level assurance, business continuity, security, storage deployment options, and operational and management tools; and to assess end user computing solutions, we looked at factors including scalability, security, storage options, ease of deployment and management, and the end user experience. To evaluate public cloud IaaS ecosystems, using specific service provider offerings as examples, we focused on attributes such as multi-tenancy, service level agreements, data protection, security, pricing, and hybrid cloud capabilities.
Taneja Group Opinion

Overall, VMware stands out as the virtualization, end user computing, and public cloud infrastructure-as-a-service (IaaS) leader for SMB customers – due to the reliability, strength and maturity of the vSphere virtualization platform; SMB tools for getting started with, deploying and managing virtualization; breadth and application focus of its end-user computing solutions; and growing service provider ecosystem for public cloud IaaS, including the ability to move and manage workloads between on-premise infrastructure and public clouds. No other vendor reviewed in our assessment is yet executing as effectively and simultaneously along all of these dimensions.

Nearly all the vendors we examined across the virtualization/cloud landscape tend to have SMB offerings in one or at most two of the relevant solution areas. Only VMware provides solutions in all three areas: leading virtualization and end-user computing offerings, plus an established public cloud IaaS ecosystem. (see Figure 1, plus table on page 1).

Figure 1: SMB Cloud and Virtualization Solutions Landscape

As we went through our assessment of the SMB solutions landscape, we kept in mind a set of challenges (summarized in Figure 2) that SMBs tell us they face in evaluating and selecting new technology solutions. These, in turn, suggest a series of top-level requirements (also listed in Figure 2) that we believe SMB buyers should demand in their chosen virtualization and cloud vendor/solutions.

Of the six vendors in our comparative study, VMware’s solutions come closest to matching the set of top-level requirements that SMBs should be looking for. VMware today provides an integrated solu-
tions family spanning on-premise virtualization, end user computing, and cloud. As we’ll see in our detailed analysis, VMware provides a rapid path for SMBs to virtualization and cloud via a set of easy to deploy and manage offerings, built on the foundation of a reliable, advanced, and widely deployed hypervisor platform. VMware’s virtualization-aware security and business continuity capabilities surpass those of the other vendors in our study, and unlike its rivals, VMware provides cost-effective, packaged solutions tailored to SMBs. VMware also provides SMBs with a non-disruptive, highly scalable growth path to protect their virtualization/cloud investments, and ensures that customers will not be locked in to a single cloud or service provider. As one of the leaders in virtualization and cloud infrastructure, VMware is not only a safe choice, but also the best choice, for SMBs.

Figure 2: SMB Challenges and Solution Requirements

<table>
<thead>
<tr>
<th>SMB Challenges</th>
<th>Solution Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>We have limited resources to plan for, adopt and learn a new technology solution</td>
<td>An easy on-ramp to virtualization and cloud, with integrated products that are simple to use</td>
</tr>
<tr>
<td>We must maintain our competitive edge, including IT agility and fast time to market</td>
<td>Flexible and innovative virtualization platform, and the ability to move workloads to cloud</td>
</tr>
<tr>
<td>We need technology that just works and is available when we need it</td>
<td>Reliable, proven, and highly available virtualization and cloud technology</td>
</tr>
<tr>
<td>Our apps and data must be secure, yet accessible to our mobile workforce</td>
<td>Virtualization-aware security, with solutions enabling secure remote access to apps/data</td>
</tr>
<tr>
<td>Our IT budgets are often quite limited</td>
<td>Solutions tailored to and priced for SMBs, which are cost effective to operate</td>
</tr>
<tr>
<td>Our IT solutions must be able to grow with us, as rapidly as we do</td>
<td>Highly scalable virtualization and cloud technology, from SMB to enterprise</td>
</tr>
<tr>
<td>We need flexibility to deploy on-premise or in the cloud, and to change cloud providers</td>
<td>Solutions that make apps h/w agnostic, and portable across on prem and cloud providers</td>
</tr>
</tbody>
</table>

With this context in mind, we have developed a series of key takeaways that will help guide your evaluation of virtualization and cloud solutions and services, and enable you to select the best vendor and solution for your growing small or mid-sized business.

**Key Takeaways for Small and Medium Business Decision Makers**

- **In evaluating cloud solutions, go beyond just “kicking the tires”.** The cloud market is still emerging, and many vendors are overpromising and under-delivering. As a buyer, you must check out whether the various offerings perform as advertised. We recommend hands-on, proof-of-concept engagements that put the offerings through their paces, and test and exercise key capabilities.

- **Start with a solid foundation.** We believe the fastest and surest route to a successful solution deployment is to choose a robust and proven underlying platform. Ask vendors and service providers about the maturity, reliability and availability of their virtualization and cloud IaaS stacks, and their experience in running customers’ business-critical workloads.

- **Insist on virtual security.** Security is one of the most critical requirements for virtualization and cloud solutions. Look for solutions that offer virtualization-aware security, versus ap...
proaches that graft existing physical infrastructure security solutions into a virtualized environment. Work with the vendor to understand their security framework, and validate that the framework addresses each layer of the virtualization and cloud IaaS stack.

- **Look for solutions that are simple to deploy and manage, but don't force compromises in efficiency, data protection, or quality of service.** Dynamic cloud environments require a new approach to management – one that is as agile and flexible as the underlying virtual infrastructure. Ask to see SMB-friendly tools for setting up and managing a virtualization environment, and for simply and efficiently backing up and patching VM workloads. Prioritize solutions that have high levels of automation and policy-based service assurance.

- **Make sure your apps are portable between on- and off-premise.** As shown in Figure 1, your cloud IaaS provider will offer much less value if your applications can’t move back and forth effortlessly between on- and off-premise. Insist on a solution that enables you to freely move and manage workloads between on-premise and public clouds.

- **Demand the freedom to choose cloud service providers.** Your solution must provide you with the freedom of choice to move from one off-premise provider to another. To make this a reality, look for vendors that are building a large ecosystem of compatible cloud providers.

- **Plan for the best of both worlds.** The most effective solutions will marry the security, quality of service and control of on-premise infrastructure, with the agility and compelling economics of a public cloud. As you evaluate solutions, focus on vendors that provide the security, cross-cloud management, standards-based workload portability and interoperability required to bridge on- and off-premise deployments.
GUIDE TO OUR LANDSCAPE ASSESSMENT

Our comparative evaluation of the virtualization and cloud solutions landscape for SMBs is divided into the following six sections:

- **Market Definition, Drivers and Vendor Landscape.** We define each of the three markets, discuss primary market drivers, and then briefly describe the solution vendor and cloud ecosystem landscapes covered in our analysis.

- **Virtualization/Cloud Vendors and Solutions Evaluated.** Here we define each of the three solution categories, our vendor selection criteria, and the vendors and solutions we have evaluated in each category.

- **Evaluation Methodology and Criteria.** This section details our evaluation methodology and the specific factors we used in each of the three solution categories to comparatively assess each vendor’s solution.

- **Virtualization and Management Competitive Landscape.** This is the first of three sections, corresponding to each solution area, in which we comparatively score the vendor offerings for each specific evaluation factor, and then discuss our rationale for the scores we have given, in a sub-section entitled “Taneja Group Opinion”. This first section details the scores and rationale for SMB-oriented virtualization and management solutions.

- **End User Computing Competitive Landscape.** In this second of three sections focused on each of the three solution areas, we comparatively score SMB-oriented end user computing offerings, and provide our rationale for these scores.

- **Public Cloud IaaS Ecosystem Competitive Landscape.** In this third and final of three sections devoted to each of the solution areas, we comparatively score three major public cloud IaaS ecosystems, and provide our rationale for these scores.

MARKET DEFINITION, DRIVERS, AND VENDOR LANDSCAPE

**Virtualization Market Definition and Drivers**

In this report we focus on the virtualization market for Type 1 (bare metal) Hypervisors, running on native x86 commodity server or desktop hardware (including both 32-bit and 64-bit variants). This is the market pioneered by VMware in 2001, and is the sweet spot for SMB virtualization efforts today. Based on our ongoing research, including regular discussions with SMB users, the three primary drivers for SMB adoption of virtualization today are reducing costs (both CAPEX and OPEX) through consolidation, improving business continuity (via the disaster recovery and high availability capabilities inherent in virtualization), and increasing IT and business agility (in conjunction with a desire to move to the cloud). Together, these factors can bring SMBs considerable benefits, enabling them to accelerate business growth, enhance competitiveness and boost profitability.

**End User Computing Market Definition and Drivers**

The end user computing market consists of those technologies and solutions that securely connect remote users (from mobile or fixed devices) with their applications and data, in a manner that provides users with access to apps/data at any time and from anywhere, and that allows IT to control and protect business information assets (apps and data) and to manage infrastructure and policies. Examples of end user computing approaches include desktop virtualization (via virtual desktop infrastructure), or VDI, user state and settings (personality) virtualization, applications virtualization, session or presentation layer virtualization (also known as server-based multi-user computing), and associated management software. The leading driver for SMB adoption of end user computing is to increase employee productivity and mobility, without compromising IT control and apps/data security.
Additional drivers include improved flexibility and agility and reducing costs, while supporting a wider variety of endpoint devices from more geographically diverse locations.

**Cloud Infrastructure Market Definition and Drivers**

Cloud computing takes many forms and is rapidly evolving from a broad range of pre-existing and new vendor technologies. The essential characteristics of any cloud computing solution are generally agreed and most understand them to include: broad network access on demand, via a self-service interface, to a pool of shared IT resources which exhibit rapid elasticity and are consumed as a measured (pay-per-use) service. Above this baseline, however, delivery and deployment models vary widely.

The major delivery models are Infrastructure-as-a-Service (IaaS, for compute, memory, storage, and network resources), Platform-as-a-Service (PaaS, for application development tools and runtime services) and Software-as-a-Service (SaaS, for applications delivered as a service). The primary deployment models include on-premise (private cloud), off-premise (public cloud), or a mix of both (hybrid cloud). In this report, we focus on public IaaS clouds, and not PaaS or SaaS clouds. While applications vary widely among SMBs, depending on factors such as their industry and type of business, infrastructure tends to be common across SMB organizations. A majority of SMBs today want to maintain control over the management and deployment of their infrastructures, and we therefore believe that SMBs should look first at IaaS clouds, rather than PaaS or SaaS clouds. A public IaaS cloud provides the benefits of cloud agility and economics, without requiring the larger investment in in-house resources needed to build and operate an on-premise cloud.

What are the primary drivers for SMBs moving to public IaaS clouds? It turns out they are very similar to the primary motivators that lead SMBs to adopt virtualization: lowering costs, increasing productivity, and enabling greater IT agility. In fact, the majority of SMBs we speak with believe that virtualization and cloud go hand in hand, and that virtualization is an essential technology for IaaS clouds.

**Solution Vendor Landscape**

Virtualization, cloud infrastructure, and end user computing solutions are offered from a wide range of vendors, but only a select group of vendors have broad portfolios of solutions that have achieved significant adoption and usage among SMBs. In the virtualization space, these players are the hypervisor vendors – VMware, Microsoft, Citrix and Red Hat – which have purchased and/or developed virtualization platforms offering a rich set of capabilities and supporting a wide range of business applications and solutions. These vendors also have private cloud infrastructure (IaaS) technologies, which often complement and enhance their SMB virtualization solutions. Not surprisingly, a subset of these leading virtualization vendors – VMware, Microsoft and Citrix – are also the leaders in SMB end user computing solutions. These suppliers provide a range of end user computing alternatives, including traditional multi-user computing (session virtualization), virtual desktop infrastructure (VDI), application streaming, and application virtualization solutions, along with accompanying endpoint and client management capabilities.

**Public Cloud IaaS Ecosystem Landscape**

The landscape of public cloud infrastructure (IaaS) ecosystems is broad and this report does not include an exhaustive list. There are three major infrastructure platform ecosystems emerging in the public cloud space: VMware vCloud, OpenStack (also representative of other open source efforts, such as around Red Hat KVM), and Amazon AWS. We have evaluated one representative service provider offering solutions (Dell Cloud with VMware vCloud Datacenter Services, Rackspace Cloud Servers, and Amazon AWS EC2, respectively) in each ecosystem, in order to explore relative platform maturity and breadth.
VIRTUALIZATION/CLOUD VENDORS AND SOLUTIONS EVALUATED

Vendor Comparative Categories
To organize our analysis and facilitate accurate comparisons with VMware’s virtualization, end user computing and cloud infrastructure service provider offerings, we have grouped competitive solutions into three main comparative categories in order to call out each vendor’s preexisting areas of expertise as well as their current virtualization and cloud strategies:

- **Virtualization and Management Solutions Category.** Solutions which offer a combination of virtualization (hypervisor platform), IT operations management tools, and opportunities to leverage cloud computing. This category also includes solutions that provide SMBs with a fast on-ramp to virtualization, along with SMB-specific IT planning, deployment and management tools.

- **End User Computing Solutions Category.** Solutions designed to remotely and securely connect users with their business applications and data, including technologies such as desktop virtualization (VDI), applications virtualization, and associated security, storage and management capabilities. This category also includes application catalogs that enable users to self-provision and launch web and SaaS applications.

- **Public Cloud IaaS Ecosystem Category.** Vendors in this category offer packaged cloud infrastructure services off-premise, on-premise and/or both, based on their own or third-party virtualization platforms. We are focusing here on public cloud infrastructure (IaaS) services for SMBs.

Vendor Selection Criteria
Since our goal is to paint a picture of the vendor landscape for SMB solutions, we have selected the top 3 or 4 vendors – in terms of SMB adoption, market share, and quality of offerings – in each of the three solution categories. As a baseline, all vendors were required to have solutions in one or more categories that are expected to be generally available in September 2012. We did not include solutions in our head-to-head comparisons that have not yet reached general availability launch, though we did consider significant upcoming offerings (e.g. System Center 2012 SP1) in our consideration of vendor strategy and some of the key takeaways that we’ve offered as a result of our assessment of vendor solutions in each category.

Vendors and Solutions Evaluated

**Virtualization + Management Solutions:**

The vendors selected for this section are the leading hypervisor players, offering virtualization platforms based on vSphere/ESX, Hyper-V, Xen and KVM technologies, and corresponding virtual infrastructure solution stacks including IT operations management, IaaS cloud, and other capabilities. These vendors actively compete in the market for SMB virtualization solutions.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Solution(s) Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMware (VMW)</td>
<td>vSphere + vCenter 5.1; Site Recovery Manager 5.1; vCloud Suite 5.1; vCenter Operations Management Suite 5.0; vCenter Protect 8.0; vCloud Networking and Security; Go Pro</td>
</tr>
<tr>
<td>Microsoft (MSFT)</td>
<td>Hyper-V 3 (part of Windows Server 2012), System Center 2012</td>
</tr>
<tr>
<td>Citrix (CTXS)</td>
<td>XenServer 6.0 (with XenCenter)</td>
</tr>
<tr>
<td>Red Hat (RHT)</td>
<td>RHEV (KVM) 3.0, RHEV-M 3.0</td>
</tr>
</tbody>
</table>
End User Computing Solutions:

The vendors selected for this section were chosen based on proven deployments of VDI, application virtualization, and other end-user computing solutions to a wide variety of customers, are generally considered to be industry leaders, and compete actively with VMware in the SMB desktop virtualization market.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Solution(s) Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMware (VMW)</td>
<td>vSphere 5.1, View 5.1, vCenter Ops for View 5.1, Horizon Application Manager 1.5, ThinApp 4.7, vShield Endpoint 5</td>
</tr>
<tr>
<td>Microsoft (MSFT)</td>
<td>Hyper-V 3 (part of Windows Server 2012), System Center Essentials 2010, VDI, RDS, USV, App-V</td>
</tr>
<tr>
<td>Citrix (CTXS)</td>
<td>XenServer 6.0, VDI-in-a-Box 5.0, XenApp 6.5, CloudGateway (with Receiver)</td>
</tr>
</tbody>
</table>

Public Cloud Infrastructure (IaaS) Ecosystems:

The service providers selected for this section are a representative sample to illustrate the types of services being offered on the three major emerging public cloud infrastructure platforms: VMware vCloud, OpenStack (representative of Open Source ecosystems), and Amazon AWS.

<table>
<thead>
<tr>
<th>Ecosystem / Service Provider</th>
<th>Solution(s) Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>vCloud (VMW) / Dell</td>
<td>Dell Cloud with VMware vCloud Datacenter Services</td>
</tr>
<tr>
<td>OpenStack / Rackspace</td>
<td>Rackspace Cloud (soon to be OpenStack-based), Private Cloud</td>
</tr>
<tr>
<td>AWS (AMZN) / Amazon</td>
<td>AWS (primarily EC2, EBS, and VPC)</td>
</tr>
</tbody>
</table>

EVALUATION METHODOLOGY AND CRITERIA

Methodology

Taneja Group performed independent research in Q3 2012, augmenting our experience with and knowledge of SMB requirements and vendor solutions with additional briefings and, where possible, demos and interviews. For each comparative solution category, we established a set of evaluation factors based on required virtualization and management, end user computing and public cloud IaaS ecosystem features and our opinion of the importance of each to the SMB buyer interested in such solutions. For each factor, we scored vendor solutions on a sliding scale: 0 = none or inadequate capabilities; 1-2 = basic, limited, or immature capabilities; 3-4 = feature-rich, broad or mature capabilities. Roll-up scores are based on a 5-point Harvey Ball scale and were calculated by averaging each factor score, then weighted by our analysis of each vendor’s virtualization and cloud focus, expertise, level of investment, and publicly-announced solution strategies and product directions.

Evaluation Factors

Following is a detailed description of the criteria we used to comparatively assess solutions in each of the three categories: Virtualization and Management, End User Computing, and Public Cloud IaaS Ecosystems. We recommend that small and mid-sized business customers use these factors to qualify, compare and contrast the functionality and capabilities of competing virtualization and cloud solutions and services.
### Virtualization + Management Factors:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Solution Features Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtualization</td>
<td>Virtualization capabilities, maturity, market penetration, hypervisor architecture. Guest OS’s and apps supported. Advanced virtualization features (mobility, HA/DR, optimizations, etc.).</td>
</tr>
<tr>
<td>Storage Deployment Options</td>
<td>Software-based shared storage solution. Non-disruptive migration to shared hardware storage as the business grows. Support for third-party SANs and NAS, and ability to leverage native array functionality.</td>
</tr>
<tr>
<td>Patch &amp; Asset Management</td>
<td>Automated inventory and management of hardware assets. Software license management. Ability to automatically scan, deploy, and manage patches from multiple software publishers. Single pane of glass to manage physical and virtual IT assets.</td>
</tr>
</tbody>
</table>

### End User Computing Factors:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Solution Features Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtualization/Core Platform as it relates to VDI</td>
<td>End user computing solutions that fully leverage capabilities of core hypervisor platform.</td>
</tr>
<tr>
<td>IT Operations and Ease of Deployment/Management</td>
<td>Ease of deploying and managing virtual desktops.</td>
</tr>
<tr>
<td>Scalability of Solution</td>
<td>Smooth, non-disruptive upgrade path to larger end user computing (VDI, etc.) infrastructure as business grows, without having to swap out products (investment protection).</td>
</tr>
<tr>
<td>End Point/Client Management and User Experience</td>
<td>No dependency on OS or other software to render user experience. Consistent user experience across different OS and software environments.</td>
</tr>
<tr>
<td>Security for Virtualized Environments</td>
<td>Non-disruptive (agent-free) antivirus and anti-malware scans of virtual desktops. Virtualization-aware security. Consistent endpoint security management interfaces for virtual and physical assets. Logging to satisfy compliance and audit requirements.</td>
</tr>
<tr>
<td>Storage Options</td>
<td>Single image management for virtual desktops (both assigned and floating). Linked clones/deduplication to significantly reduce capacity needs. Read-based caching to reduce/eliminate boot storms.</td>
</tr>
<tr>
<td>Application Virtualization</td>
<td>Agentless. Reduces the number of master images within VDI deployment. Eliminates application conflicts. Enables SMBs to embrace legacy applications and migrate to Windows 7.</td>
</tr>
<tr>
<td>Solution Cost</td>
<td>Relative cost per desktop for acquisition, implementation, and initial operations.</td>
</tr>
</tbody>
</table>
### Public Cloud Infrastructure (IaaS) Ecosystem Factors:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Solution Features Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-Tenancy Capabilities</td>
<td>Support of logical shared resource pools. Full isolation and security of different tenants and workloads. Quality-of-service controls to avoid “noisy neighbor” issues.</td>
</tr>
<tr>
<td>Multi-tiered, Enterprise-Class SLAs</td>
<td>Multiple service level tiers, providing availability guarantees for different classes of workload. SLAs that are suitable for business-critical workloads, with quantified resource (memory, CPU, disk) and availability guarantees.</td>
</tr>
<tr>
<td>Assured Data Protection</td>
<td>Automated backup and recovery to protect cloud-based workloads. Multi-site disaster recovery capabilities.</td>
</tr>
<tr>
<td>Transparent Pricing, Metering and Billing</td>
<td>Published rate card(s) for services (vs. a custom-priced contract). Monthly (or more flexible) billing, including documentation of resource usage and associated charges.</td>
</tr>
<tr>
<td>Support for Dedicated (Virtual Private) Infrastructure</td>
<td>Ability to place applications on segregated (single-tenant) physical infrastructure for compliance or performance purposes.</td>
</tr>
<tr>
<td>Workload Compatibility Between On- and Off-Premise Infrastructure</td>
<td>Ability to manage and move workloads to and from on-premise infrastructure and cloud service providers.</td>
</tr>
<tr>
<td>Service Provider Cloud Expertise</td>
<td>Documented reference architectures, best practices, and roadmaps for public and hybrid cloud infrastructure-as-a-service deployments.</td>
</tr>
</tbody>
</table>

### VIRTUALIZATION AND MANAGEMENT COMPETITIVE LANDSCAPE

<table>
<thead>
<tr>
<th>Virtualization + Management Factors</th>
<th>VMW</th>
<th>MSFT</th>
<th>CTXS</th>
<th>RHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtualization/Core Platform</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Service-Level Assurance</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Business Continuity</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Tools to Plan, Deploy, and Manage Virtualization</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Infrastructure Operations Management</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Storage Deployment Options</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Patch and Asset Management</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Security for Virtualized Environments</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>OVERALL SCORES:</strong></td>
<td>3.8</td>
<td>2.6</td>
<td>1.5</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Taneja Group Opinion

Each of the four major hypervisor vendors, VMware (with vSphere), Microsoft (with Hyper-V), Citrix (with XenServer), and Red Hat (with KVM-based RHEV), provides a platform with at least basic server virtualization and associated management capabilities. Each of these vendors also markets solutions to a wide range of customers, from small organizations to large enterprises. In our assessment, we focused on the SMB-specific capabilities of each vendor.

While total solution cost should be on every SMB’s short list of key qualifying criteria, the set of features and capabilities that make up each solution will be an equally important determinant of value. As we evaluated the virtualization solutions against our checklist of key capabilities, we noted that VMware provides a packaged set of vSphere Essentials and Acceleration Kits that are tailored to and priced for SMB users. Microsoft offers SMB buyers Microsoft System Center Essentials 2010 (with SCE 2012 currently in beta), which includes some virtualization management capabilities but is not yet designed to work with Hyper-V 3. Microsoft also offers System Center 2012 for mid-sized and larger companies, but once again, the System Center 2012 virtualization management capabilities won’t fully support Hyper-V 3 until the release of System Center 2012 Service Pack 1, which is not expected until late 2012 or early 2013. These timing issues have impacted our evaluation of Microsoft’s virtualization and management offerings. When available, System Center 2012 SP1 will need to be purchased in addition to the Hyper-V virtualization platform. Hyper-V is available either as part of Microsoft Windows Server or as a standalone hypervisor. Neither Citrix nor Red Hat provides SMB-specific virtualization offerings.

As the result of our overall evaluation of these four vendors’ portfolios, VMware emerged as the clear leader in providing virtualization solutions that are both highly functional as well as SMB-friendly. VMware provides the most mature and proven server virtualization platform, with 10+ years of production usage by SMBs and enterprises alike. VMware is the only firm among the four that started out as a pure-play virtualization player, and the company continues to be focused solely on the virtualization and cloud solutions space.

Microsoft Hyper-V has a four-year history, and its architecture is closely tied to the Windows Server operating system. Microsoft’s current virtualization platform, Windows Server 2008 R2 with Hyper-V, is a bit long in the tooth, having been released in April 2011. Though a new production release of Hyper-V (Hyper-V 3) will likely be available in September 2012, users will not be able to take full advantage of new Hyper-V 3 features until System Center 2012 SP1 undergoes GA release, which is not expected until late 2012 or early 2013. SMB buyers should also consider the impact of Hyper-V’s dependencies on Windows Server, and in particular, decide whether they can live with the multi-year cycle for major releases, which limits the rate at which Microsoft can bring new virtualization capabilities to market.

Based on the open-source Xen hypervisor, Citrix XenServer itself was open sourced in late 2009, though Citrix still licenses advanced versions of the product, including XenCenter management. Though Citrix certainly views server virtualization as an important enabling technology in the context of its broader strategy, we don’t get the sense that XenServer itself is a focal point of Citrix innovation, though the company does continue to introduce new releases on a regular basis. Relative to vSphere, XenServer has only limited use among SMB and enterprise customers in supporting production applications.

Red Hat Enterprise Virtualization (RHEV) is the relative newcomer among major hypervisor offerings, having first come to market in November 2009. Though RHEV is based on the open-source KVM distribution, Red Hat provides substantial value-added functionality in its commercial version of the technology. As with Citrix XenServer, Red Hat regularly releases enhanced versions of RHEV, though of the four leading hypervisors, the platform has the smallest adoption rate among SMB customers.
RHEV-M, the management component of RHEV, is built on Red Hat Enterprise Linux (RHEL), which SMB customers must license for an additional fee.

With this backdrop in mind, SMB buyers should consider the following takeaways as they go through their evaluation and purchasing process:

- **Virtualization is an essential foundation technology for the cloud.** Virtualization can bring tremendous benefits to SMBs, such as increased server utilization, cost savings through consolidation, and greater IT and business agility. But we believe that virtualization is also an important enabling technology for – and first step towards – the cloud, since workloads must be decoupled from the physical infrastructure, consolidated, and optimized before they are cloud ready.

VMware leads in this category, with its market-leading vSphere hypervisor, superior virtualization capabilities, and track record in production environments. Microsoft Hyper-V has found favor among loyal Windows customers, but vSphere still far outpaces Hyper-V in terms of deployed production workloads, application support statements, and overall market presence. In addition, Hyper-V is architecturally dependent on the Windows OS, which greatly expands its footprint and attack surface area relative to vSphere, and also slows innovation by tying new virtualization features to the multi-year Windows release cycle. Citrix XenServer is now an open source technology, but is lagging behind vSphere in terms of SMB adoption and features. Red Hat partially closed the functionality gap between RHEV and vSphere with its latest 3.0 release, but does not offer a package tailored to SMBs, and still has a limited installed base among SMB customers.

- **You cannot afford to gamble with business-critical applications.** You would never leave quality of service to chance in your physical infrastructure, and you shouldn’t in your virtual one, either. To provide service-level assurance in a virtual infrastructure, the hypervisor must provide dynamic allocation of CPU, memory, storage and networking from a set of logical resource pools, so that VMs running business-critical applications will not be starved for these resources when they are most needed. Dynamic resource allocations can be managed and implemented through policy-based automation capabilities. Host and storage I/O profile capabilities enable you to standardize configurations of new virtual hosts and datastores, to help ensure that the resources are available to meet service-level needs of high-priority applications.

VMware vSphere 5.1 Enterprise Plus Acceleration Kit sets the standard for service-level assurance for SMBs, with features such as Distributed Resource Scheduler (DRS) and Storage DRS, which enable IT resources to be dynamically allocated, and features like Storage I/O Control and Network I/O Control, which allow administrators to set policies that govern how resources are allocated to competing VMs. A number of the vSphere resource management capabilities go beyond an individual host, and apply at the cluster level. Microsoft Hyper-V 3 does not provide logical resource pools across host clusters, even with System Center 2012 SP1, and cannot dynamically allocate storage resources to critical VMs. Citrix XenServer and Red Hat RHEV offer basic resource sharing, but no ability to allocate storage or networking resources to high-priority VMs. Microsoft, Citrix and Red Hat also do not provide host or storage I/O profile capabilities.

- **Business continuity is as essential for the SMB as it is for the enterprise.** Your virtualization solution should contain built-in high availability and fault tolerance features, to minimize downtime in the event of an unplanned system failure or outage. The solution should also provide offsite or cloud backup, replication, and automated recovery capabilities, so that you can recover from a disaster that disables your primary site. Finally, the virtualization solution
should enable you to non-disruptively migrate your VMs (running or idle) and virtual server storage, to prevent application downtime due to planned maintenance activities.

Microsoft Hyper-V 3 provides the majority of these capabilities to SMBs, including non-disruptive, live VM and virtual disk migration. However, Hyper-V 3 does not offer a fault tolerance solution to match vSphere's FT capability. Citrix XenServer and Red Hat RHEV deliver high availability and non-disruptive live migrations of VMs out of the box, but cannot perform live migrations of virtual disks, nor do they offer built-in backup and replication to facilitate rapid recovery. VMware vSphere delivers nearly all of these capabilities in the Standard Acceleration Kit for SMBs, through features such as VMware HA, vMotion, Storage vMotion, Data Protection and vSphere Replication. SMB users who need automated failover and failback and non-disruptive DR testing capabilities can license vCenter Site Recovery Manager (SRM) for an additional fee.

- **Virtualizing shouldn't be a trial-and-error exercise.** One of the frustrations we hear from SMBs is that their virtualization supplier did not provide them with enough help and guidance upfront, so that they could readily identify the best candidates for virtualization from among their physical server workloads, and easily install, set up and manage their virtualization environment. These SMBs had to read through detailed technical documentation, and in some cases, resort to trial and error approaches to get their environments working. To address this requirement, we believe that virtualization providers should include sufficient tools to automate workload discovery, selection and conversion, as well as wizards to enable IT generalists to set up and manage the initial deployment.

VMware includes in its cost-effective Go Pro offering the toolset to accomplish nearly all of the above, so that SMBs can be more productive in taking their first steps toward virtualization. VMware enables cross-cloud migration with its vCloud Connector offering. Though Microsoft on paper provides most of these virtualization planning and deployment capabilities in Hyper-V 3, System Center Essentials 2010 and/or System Center 2012, the System Center offerings do not yet fully support Hyper-V 3, so Microsoft customers will not have a good solution here until such support is offered. Even when System Center 2012 SP1 becomes available, it appears that cross-cloud migration capabilities will still be lacking. Citrix offers quick install and set-up and workload conversion, though does not provide a guided assessment nor tools tailored to SMBs. Red Hat has the weakest offering here, with only third-party workload conversion and very little in the way of handholding to help SMBs get started on the right foot.

- **Strive to put your virtual infrastructure on auto-pilot.** It takes a strong and well-integrated management toolset to keep a virtual infrastructure running smoothly and effectively. But beyond that, it takes built-in intelligence and automation, since an SMB customer will typically have only limited time and expertise to master and play a hands-on role in day-to-day management. For this reason, we looked for built-in performance monitoring, capacity metering, and operations dashboards as we assessed each solution. Since a virtualization deployment is never static, we also checked for features such as dynamic performance thresholding and self-learning analytics, as well as the ability to correlate performance with change events. Finally, since users really care most how their own applications are performing, we evaluated solutions for application visibility and awareness.

Microsoft gets partial credit in this category, since both System Center 2012 and System Center Essentials 2010 provide many of these management features, though neither System Center offering fully supports Hyper-V 3. When such support becomes available, SMB customers will have to license the more expensive System Center 2012 SP1 to gain access to performance monitoring, capacity usage metering, and performance/change correlation capabiliti-
ties. Even when full System Center 2012 support for Hyper-V 3 is available, dynamic performance thresholds and self-learning performance analytics will not be offered. Though Citrix and Red Hat have basic monitoring and dashboards, and Red Hat has limited capacity metering, they lack most of the other management features, so they score less well. VMware, with its vCenter Operations Manager, available to SMBs in the Standard Acceleration Kit with Operations Management, is able to deliver all of these operations management capabilities, though the price may be on the high side for smaller SMBs.

- **Demand a virtualization solution that fits your current storage deployment and budget.** Storage is an essential part of a virtual infrastructure, and should not be an afterthought in planning or deployment. Moreover, a virtualization solution should largely be able to adapt to your own type of storage, whether it is networked via a SAN or NAS, or direct attached to your servers. SMBs we speak with tend also to look for low-cost storage, and many are unable to invest in networked storage to kick-start their virtualization initiatives. As a result, we were looking in this category not just for basic third-party array support, but also for low-cost software-based storage solutions, as well as the ability to migrate easily to shared hardware storage as a business grows.

All four vendors score well in third-party array support, and Citrix and VMware get extra credit by allowing SMBs to directly leverage native array functionality (with VMware, this capability is available in Enterprise and Enterprise Plus Acceleration Kits). Microsoft Hyper-V 3 also enables users to take advantage of some native array features. Microsoft Hyper-V 3 and VMware vSphere 5 offer migration to shared SAN or NAS storage; Citrix XenServer 6 and Red Hat RHEV 3 cannot provide this capability. In SMB environments without SAN or NAS storage, vSphere 5 and Hyper-V 3 can provide a low-cost, software-based, shared storage option (in VMware’s case via the vSphere Storage Appliance which is included in vSphere Essentials Plus Kit), while RHEV customers have the option of using an inexpensive, open source NFS array to meet this same need. Overall, VMware and Microsoft earn the highest overall marks in this category.

- **SMB customers cannot afford expensive add-ons for essential patching and asset management functions.** As you evaluate competing virtualization solutions, it pays to look closely to see whether they include basic administrative functions that you likely take for granted in your physical infrastructure. For example, does the virtualization solution enable you to inventory and manage your hardware assets? Does it allow you to easily manage your software licenses? How about patching? Do you have the ability to scan for, schedule and deploy software patches for both Windows and third party applications, for either virtual or physical devices? Are all of these management capabilities for your physical and virtual devices accessible from a single management console?

Based on our assessment, you’ll likely find a varying degree of coverage for these capabilities among the four vendors’ solutions. Citrix provides hardware inventory and software license management, but only via XenCenter plug-ins to third party packages, and manual patching capabilities are available only via purchase of XenServer 6.0 with Essentials Enterprise, which is beyond the cost and scope of most SMBs. Microsoft provides hardware inventory management and single-pane-of-glass visibility in System Center Essentials 2010, but patch management and software license administration are only available in System Center add-ons, and SCE 2010 doesn’t work with Hyper-V 3. Red Hat RHEV-M offers a single administrative view of physical and virtual assets, but cannot deliver any of the other capabilities. Depending on your environment, vCenter Protect, included in vSphere Standard with Operations Management Acceleration Kit, and VMware Go Pro go further than any of the competing offerings, and deliver the full complement of administrative functions in a cost-effective solution.
To be effective, security must be built in – versus bolted on – to the virtual infrastructure. Security is consistently cited among SMB’s top concerns about moving to virtualization and the cloud. While most vendors recommend using existing physical security features and tools with their virtualization offerings, we believe the best approach is to design those capabilities in from the beginning, so that the security is virtualization aware. In this category, we evaluated solutions based on whether they offer a comprehensive security framework, along with logical firewalls that operate at a virtual network interface card (vNIC) level and protection for VM-based applications from network-borne threats. We also assessed whether solutions provide a non-disruptive antivirus (AV) model, to avoid both AV storms and in-guest performance issues.

VMware gets a high overall mark here, with its virtualization-aware security, vCloud Networking and Security functionality, and comprehensive security management framework. vShield Endpoint is now available to SMBs as part of the vSphere Essentials Plus Kit and vSphere Acceleration Kits. Microsoft Hyper-V 3, with its built-in parent OS and lack of security at the logical boundaries between VMs and applications, cannot provide the level of virtualization-aware security that VMware does. Offerings from Microsoft, Citrix and Red Hat tend to employ OS-driven approaches and best practices to try to secure the virtualized environment (e.g. Microsoft with Windows, Red Hat with RHEL). Hyper-V 3 has some new security capabilities, such as extensible vSwitch, ACLS, and private VLANs, but still lacks a central management capability, which System Center 2012 SP1 won’t address. The three vendors’ security frameworks are limited and not well integrated, and features such as virtual/logical firewalls aren’t possible without going to third parties.

### END USER COMPUTING COMPETITIVE LANDSCAPE

<table>
<thead>
<tr>
<th>End User Computing Factors</th>
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<th>CTXS</th>
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**Taneja Group Opinion**

With the growing trend to support Bring-Your-Own-Device (BYOD) to work, an increasingly distributed and mobile workforce, and the ever increasing pressures on IT to provide faster provisioning
with a better, more consistent end user experience, End User Computing capabilities are quickly becoming key components in the SMB arsenal. With the best desktop virtualization solutions, IT can better secure data and devices, upgrade applications, migrate operating systems, and provide better service, all with greater agility and at lower cost per user than with physical desktop deployments. End User Computing as we consider it in this report encompasses the various virtualizing technologies used to deliver applications and/or desktop experiences to end users.

By virtualizing applications and desktops, IT can take advantage of master image management on shared storage and pooled virtual server infrastructure, with internal data security and centralized user access controls, while enabling a productive, self-service user experience from almost any type of endpoint access device. Today’s application and virtual desktop performance can be remarkably fast, and in many instances can be significantly better than using a locally installed application or desktop.

VMware leads the pack in SMB-scale desktop virtualization for a number of reasons including offering a single comprehensive solution that scales smoothly, provides easy-to-manage, enterprise-class features for the core platform, and delivers a fully consistent end-user experience across devices and locations. VMware’s end user computing components considered here include VMware View on vSphere, Horizon, Thinapp, vShield Endpoint and vCenter Operations Management.

VMware’s main competition in End User Computing comes from Citrix and Microsoft. Citrix is a long-time provider of desktop virtualization for the enterprise based on their Xen family of products. Citrix additionally supports SMB customers with Kaviza VDI-in-a-Box solutions. While the VDI-in-a-Box solution is uniquely packaged as a simply managed clusterable virtual appliance that supports “grid-like” VDI solutions, other Citrix components like XenApp and Receiver are needed to build a complete Citrix end user computing solution, making it complex to implement and manage. VDI-in-a-Box can be hosted on VMware vSphere, Citrix XenServer, or Microsoft Hyper-V.

Microsoft offers its own range of end-user computing solutions in the form of VDI on Hyper-V, Remote Desktop Service (RDS), and App-V, along with a few other components like USV (User State Virtualization), MED-V for migration to Windows 7, and management from Microsoft Systems Center solutions. Since many desktops being virtualized are Windows based PC’s, many of the client OS features of Microsoft’s end user computing architecture like User State Virtualization are available for those Microsoft desktops served by either View or VDI-in-a-Box.

- **Optimal desktop virtualization leverages core platform capabilities.** It’s entirely possible to obtain distinct virtualization technologies for servers, applications, sessions, and desktops, and then mix and match them across vendors in a production deployment. However, significant opportunity is lost when hypervisor-agnostic virtual desktop implementations don’t take advantage of native hypervisor features. VMware View can benefit from all the features of vSphere including vMotion, Storage vMotion, VAAI, and vCenter management (collectively available to SMBs in vSphere Standard or Enterprise Acceleration Kits), and desktops running as VM’s on vSphere can be intimately managed with memory management, clock controls, and other integrations.

  Citrix’s VDI-in-a-Box is essentially hypervisor agnostic, and can run on XenServer, Hyper-V, or vSphere. While it is designed to be self-contained, this independence also means there is little deeper integration with hypervisor capabilities. Microsoft has recently improved their core platform to enable Virtual Desktop Infrastructure (VDI) to utilize Remote FX and the Dynamic Memory features in Windows Server 2012 with Hyper-V 3.

- **Ease and simplicity are key for SMB IT organizations.** For SMB users, rolling out a desktop virtualization implementation can be daunting - even more so when a small IT shop becomes
responsible for maintaining the critical shared infrastructure that now provides users with their fundamental desktops and applications. VMware’s View Manager provides a single centralized console for managing users and data, and setting policies for users or groups of users. VMware View additionally leverages vCenter for Desktops, enabling cohesive management across the server and desktops. Citrix VDI-in-a-Box is straightforward to manage by design with all VDI specific management converged into one appliance, and scores high for initial simplicity and SMB ease of deployment and use, although subsequently lacks features for optimizing infrastructure utilization, assuring consistent performance, and managing desktops at scale. Microsoft offers System Center Virtual Machine Manager with System Center Operations Manager that enables allocation of VMs based on either performance needs or resource assignments, but is also missing key features for infrastructure and performance maximization.

- **Organizations grow and so must end user computing solutions.** VMware offers the most scalable solution, leveraging a common platform and the same desktop virtualization components as business needs grow. This non-disruptive upgrade path scores highest for investment protection as a business grows. Microsoft’s scaling strategy embodies a fundamental split made between desktop intensive “knowledge-based” VDI users and the lighter weight Remote Desktop Services session-based virtualization for scaling up task workers. This does enable a simple level of resource allocation based on worker type, but as SMBs grow they are not necessarily going to expand support for task-based workers alone. VDI-in-a-Box appliances have easy initial scalability for an SMB because you can simply add another appliance when necessary, but due to the simplified approach at growing scales both system bottlenecks and larger scale management issues can arise. While Citrix offers a license trade-up, there is no technical migration path from VDI-in-a-Box to its big brother XenDesktop solution – reaching that milestone in growth becomes a serious rip-and-replace challenge.

- **Users want a consistent experience on any device, anywhere.** A great user experience is key to the successful adoption of desktop virtualization solutions. There are at least two differing approaches to delivering a great user experience – either optimize delivery tailored to each end point’s capabilities, or strive to deliver a completely consistent experience no matter the end point. A seamless user experience better meets human psychological expectations for service quality, but the consistent approach still has to deliver good perceived performance. Another concern is the implied waste of local client capabilities but if you can deliver a great experience with server-side processing the point is mute.

  We score VMware’s approach as most consistent, with server side rendering even independent of the server having a GPU (using Soft3D, a virtual graphics processor and PCoIP). Citrix is a tough competitor here, however, with long experience leveraging local end point capabilities and Adobe Flash support where available (using HDX/ICA and even Windows RemoteFX), with a fallback to server side rendering. Microsoft has an interesting approach virtualizing server GPU (with RemoteFX over RDP), but end points are limited to Windows clients unless third party software is involved.

- **Security functions should take advantage of shared images and centralized control.** One of the biggest performance bottlenecks with lots of virtual desktops sharing a central pooled infrastructure occurs when each virtual desktop simultaneously performs a scheduled activity like anti-virus (A/V) scans. The best approach to date is to implement virtualization-aware security features that take advantage of behind-the-scenes virtualization features like master desktop images and dynamic “hooks” into each running VM. Anti-virus scans can operate on the master images offline, and by hooking into each VM, security programs can operate without desktop agents.
VMware’s vShield Endpoint, available to SMBs through the vSphere Essentials Plus Kit, supports running A/V scans from a central security VM to avoid both anti-virus “storms” and agent sprawl. Endpoint can also produce thorough aggregated compliance and audit logs of anti-virus tasks and other anti-malware activity. Neither Hyper-V VDI nor VDI-in-a-Box offers these types of security features or capabilities directly, although third party add-ons are available that can be layered on with additional cost and complexity.

- **Both performance and capacity storage challenges can stall VDI implementations.** Storage issues are one of the biggest challenges for successful SMB virtual desktop implementations. The previously mentioned anti-virus storms, initial boot storms, sprawling numbers of desktop images, backup bottlenecks, and other data protection issues all descend on the storage subsystem under VDI. A key feature we rate highly significant in addressing capacity issues is single image management, which both View and VDI-in-a-Box provide at some level. View’s Composer implementation of “linked clones” assembles desktop images at runtime from OS images, user data disks, and application images to maximize the use of underlying storage resources. This approach enables easy mass-desktop refresh and non-disruptive patching. VDI-in-a-Box has a simpler type of linked clones that only addresses the base desktop image, leaving user data and “other” storage managed independently.

VMware View Storage Accelerator, aka Content Based Read Cache (CBRC), is an example of VMware’s technology leadership addressing storage performance from the virtualization layer. It provides a large, static in-memory read cache that handles the daily boot storm, login storm, or legacy style virus scans that execute directly within each guest desktop. VDI-in-a-Box replicates each desktop image across servers within its grid providing some fault tolerance and bottleneck avoidance by the spreading of IO, but this approach to replication at growing volumes can inefficiently chew up total capacity.

Microsoft VDI doesn’t weigh in with comparable storage features, but Hyper-V does offer “differencing disks” that can be used for VDI images. However, these disks in their unexpanded state would tend to be a performance bottleneck, and once expanded would use up capacity.

- **Further reduce costs by delivering virtualized applications.** Application virtualization solutions could be considered a separate capability from VDI but they are often deployed together to provide a complete and coherent end user computing environment. In some scenarios an end user could be simply provisioned with virtual applications in lieu of a full virtual desktop, but we focus here on application virtualization that augments or layers on virtual desktops. Some key evaluation criteria for application virtualization solutions include the need for agents, master image management, run-time isolation and support for legacy apps.

VMware’s ThinApp, Microsoft’s App-V, and Citrix XenApp all deliver virtualized applications that run in isolated containers to eliminate application conflicts. We score ThinApp higher because it’s agentless and its virtualized apps run in user mode, whereas XenApp and App-V both require client agents. Additionally, it’s worth mentioning that the Windows 7 migration use case is directly supported by ThinApp, while Microsoft requires MED-V to export Windows XP VMs to support legacy apps and XenApp’s approach to migration is through session virtualization.

- **Empower users with self-service catalogs that unify access to virtualized, web, and SaaS applications.** IT should present one simple, unified access point where end users can easily access all their applications. Both VMware’s Horizon and Citrix Receiver support defined virtualized, web, and SaaS delivered apps, and both can support single sign-on, but Horizon includes the ability to provision and de-provision SaaS accounts. Horizon is also available in both an on-premise and a SaaS version, which could be a good option for many SMB custom-
ers. Microsoft’s RDS contains the Remote Desktop Connection Broker that provides a single-page access to remote desktop sessions, RemoteApps, and virtual desktops, but doesn’t support web or SaaS applications.

- **Keep an eye on the costs of ownership, including operations and management.** SMB customers need to be incredibly cost conscious about the total cost per desktop. The best solutions today provide a better performing, more widely accessible and productive virtual desktop at a lower cost than a physical one. But the risk is also high, as there is little room for experimentation or error with a desktop access point that is shared by all users. Desktop virtualization must provide the capabilities needed to deliver it as a mission-critical service.

Citrix VDI-in-a-Box, which is designed for the entry-level use case, has a low initial cost of acquisition, and so does Microsoft, depending on how buyers look at a full VDI implementation project. VMware View, with its bundled platform and management capabilities, is competitively priced from an upfront licensing standpoint, and given its high level of manageability and operational assurance at scale, may well provide the lowest total cost of ownership over the life of a customer’s deployment.

### PUBLIC CLOUD IAAS ECOSYSTEM COMPETITIVE LANDSCAPE

<table>
<thead>
<tr>
<th>Public Cloud IaaS Ecosystem Factors</th>
<th>VMW vCloud (Dell)</th>
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*Note: we have not evaluated Rackspace on its vSphere-hosted offering in this report.*

**Taneja Group Opinion: Comparing Service Providers in Three Major Ecosystems**

The three leading cloud ecosystems today—driven by Amazon, Rackspace/OpenStack, and VMware—are each designed for a different audience and purpose. Amazon created the commodity cloud market, based on the proprietary AWS IaaS stack targeted at software developers, and has built a rich ecosystem. Rackspace is augmenting its highly-regarded Cloud Servers and Virtual Private Cloud services with its OpenStack ecosystem, and is open sourcing its public cloud development going forward under the OpenStack initiative. VMware is creating an ecosystem of certified vCloud service providers, which can offer cloud services to a range of customers, from SMBs to large enterprises.
In this study, we have evaluated a representative service provider in each of these three cloud ecosystems. In the case of Amazon and Rackspace, we assess the service capabilities of each of these public cloud providers, since neither company has built relationships with strong and independent third party service providers. VMware, on the other hand, has developed the vCloud Datacenter Services program, and has attracted and certified a number of leading service providers that are now delivering vCloud services.

Dell is an outstanding example of such a service provider. Dell Cloud with VMware vCloud Datacenter Service is enterprise-class Infrastructure-as-a-Service (IaaS) hosted in a secure Dell data center. This service provides SMBs with access to vCPUs, memory, storage networks, IP addresses, firewalls, catalog capabilities, and additional services. Dell is among the first to provide full hybrid cloud capabilities, enabling SMBs to extend their internal data center by transitioning VMware virtualized workloads into Dell’s vCloud data center. This capability helps to enable use-case scenarios such as dev/test, cloud-based DR, and cloud-bursting of workloads during peak-demand periods. On-demand capacity allows SMBs to quickly respond to new business opportunities, seasonal/cyclical trends, and other fluctuations in the need for compute capacity. Mobile users have anytime access to the public Dell IaaS cloud from multiple devices. The vCloud-based public Dell Cloud provides compute, storage and network resources as a service to support any application, including business-critical workloads, and all Dell services under this offering meet the rigorous certification requirements of the VMware vCloud Datacenter services definition.

**VMware/Dell sets the standard.** The VMware-Dell service provider partnership highlights some of the differentiators of the vCloud Datacenter Services program that make it attractive to a range of users, and set VMware’s public/hybrid cloud service provider program apart from all others:

- **Fast time to deployment:** SMBs can get their vSphere-based workloads up and running on Dell-hosted IaaS in a matter of days or less, simply by converting them to the Open Virtualization Format and uploading them to the Dell Cloud.

- **Multi-tenancy capabilities.** Dell public cloud customers enjoy the benefits of VMware multi-tenancy, built on vSphere and vCNS technologies. Based on VMware’s strong built-in isolation and security between different tenants and workloads, along with cpu, memory, storage and network resource controls to ensure quality of service for SMBs’ most critical applications, VMware vCloud multi-tenancy is among the best in the industry.

- **Transparent and auditable security.** The solution is protected by a combination of VMware’s vCNS security framework, which is fully virtualization aware, and Dell SecureWorks Active Monitoring. vCloud Datacenter Service includes SAS 70 Type II or ISO 27001 compliance, virtualization- and application-aware firewall capabilities, Layer 2 isolation, role-based access control, and Active Directory integration. Dell SecureWorks Active Monitoring service delivers around-the-clock, real-time monitoring, correlation and expert analysis of security activity for SMB workloads running in the Dell Cloud.

- **Dedicated infrastructure.** Dell provides the option for SMBs to dedicate public cloud infrastructure to business-critical workloads that need to be isolated for compliance purposes, or that require the highest possible quality-of-service levels. Dell’s Dedicated service tier (described below) enables more predictable performance by ensuring that resources are always available as needed for SMB’s most performance-sensitive applications.

- **Multi-tiered enterprise SLAs.** Dell offers SLAs in three different tiers. The first level, which most SMBs choose for their workloads, is Pay-As-You-Go, a multi-tenant service that enables an SMB customer to place vSphere workloads on Dell’s cloud on a month-by-month basis. The second tier is Reserved, a multi-tenant service with a 1-year minimum commitment in which
a customer can ask Dell to set aside a fixed amount of cloud capacity for their use. The third and most stringent tier is Dedicated, a single-tenant service with a 1-year minimum commitment in which a customer’s workloads can occupy entire servers for their VMware vCloud environment. The Dell SLA is tougher than most cloud SLAs, in that it specifies full workload availability. If a customer’s workloads are not available at least 99.95% of the time, excluding Dell-scheduled maintenance, then Dell will provide a credit for the downtime incurred.

- **Global consistency and reach.** Dell offers a consistent set of public Dell vCloud Datacenter services from its United States-based datacenters today, and plans to expand the service internationally later in 2012.

- **Freedom of choice and application portability.** Because all vCloud Datacenter Service offerings are built on the same compatible VMware technology, they provide the interoperability and portability needed for SMBs to deploy workloads across on-premise infrastructure and public clouds, and to move workloads from cloud to cloud as needed.

- **Enterprise-level, public/hybrid cloud expertise.** The vCloud Datacenter Services program provides a set of rigorous training and certification services, and requires Dell and other participating service providers to meet enterprise-level standards for security, agility and application-level portability. Certified vCloud Datacenter Service Providers such as Dell provide SMB customers with the benefit of their considerable expertise, in the form of best practices, reference architectures, and implementation services.

### Amazon and Rackspace lack in security, SLAs and hybrid cloud capabilities.

Let’s briefly compare the Amazon and Rackspace cloud service provider offerings against this VMware/Dell standard:

- **Lack of enterprise-grade security.** Both Amazon and Rackspace provide security that is acceptable for public cloud developers, including basic identity management and role-based access controls, but nowhere near the robust offering provided by VMware/Dell. Amazon and Rackspace run on a Xen-based virtualization platform, which suffers from the inherent vulnerabilities of a Dom0 architecture and built-in parent OS. These public cloud providers also do not offer the virtualization-aware security that VMware vSphere provides at the logical boundaries between VMs and applications.

- **Weaker multi-tenancy than VMware vCloud.** Both Amazon and Rackspace enable the sharing of underlying physical resources, as well as isolation of VM instances running on the same physical machine. But these public cloud providers do not provide true logical resource pooling, since they must dedicate hosts to tenants to guarantee resource availability. Amazon AWS and Rackspace Cloud also do not offer the granular resource controls that vSphere does, preventing them from ensuring quality-of-service levels for SMB customers’ high-priority applications.

- **SLAs are single tier, not enterprise class.** Both public cloud providers offer single-tier SLAs, versus the multi-tier SLAs provided by Dell and other vCloud Datacenter service providers. Rackspace guarantees 100% network uptime, excluding scheduled maintenance, and 1-hour restoration of cloud server hosts in the event of failure, but does not provide a specific commitment for workload availability. Amazon’s SLA is particularly weak, since its availability commitment is based merely on the ability to start new instances, a much weaker standard than Dell’s hard commitment for 99.95% availability of all running workloads. In fact, Amazon AWS is designed to allow instances to fail, meaning that customers running business-critical applications on AWS must build high availability and redundancy into their applications. Though enterprises like Netflix can afford the large (in the case of Netflix, multi-million dollar) investment to do this, this would be a tall order for SMBs. Instead, we recommend that...
SMBs work with a service provider that can guarantee uptime and performance for their critical applications.

- **Rate cards are often more complicated than they first appear.** We have given all three public cloud providers a high score on the transparency of their pricing, metering and billing of services. However, we counsel SMBs to take the time to thoroughly understand all of the charges they will be incurring before they sign up for a public IaaS cloud service. For example, Amazon AWS offers a low cost per hour for compute capacity, but adds on a number of other charges to a customer’s bill over time, including storage, data transfer and networking charges. The bottom line: SMBs should be thorough in their cost comparisons, and look at total cost of ownership versus just initial service acquisition costs.

- **Lack of global consistency and reach.** Amazon AWS has significant worldwide reach and presence, but not necessarily consistent IaaS services across each of its geographic regions. For example, Amazon AWS has set up multiple “Availability Zones” for EC2 customers in each of its eight Regions around the world, and yet the AWS SLA gives Amazon significant wiggle room to have several Zones down at any given time and still be able to meet its SLA commitment. Rackspace began to migrate its public cloud customers to the OpenStack cloud platform in August 2012, but has yet to build a globally consistent set of IaaS offerings. Rackspace is still in the early stages of expanding its offering outside the US; its European cloud initiative was only launched in January 2011, and the company now has data centers in the UK and Hong Kong. While the company has a thriving hosted services business in Europe, it is based mostly on vSphere—and not OpenStack—today.

- **In the case of Rackspace, no dedicated (virtual private) infrastructure that is compatible with public cloud offering.** Rackspace does offer a VMware-based Rackspace Private Cloud, but since workloads cannot be freely moved today across Rackspace public Cloud Servers and Rackspace Private Clouds, this is not a true hybrid cloud solution. Amazon now offers a production version of AWS Virtual Private Cloud (VPC), which provides a virtual private cloud with the option for dedicated infrastructure, using Dedicated Instances. Customers can migrate workloads between VPC and AWS public cloud infrastructure, though this requires some network set-up and is not encouraged by Amazon.

- **No hybrid cloud capabilities today.** This brings us to the most important point: neither Amazon nor Rackspace can offer true hybrid cloud capabilities today. Though AWS customers can set up a hardware-based Virtual Private Network (VPN) to connect their on-premise infrastructure with an Amazon VPC, Amazon does not provide customers with an on-premise cloud. And due in large part to Amazon’s proprietary EC2 environment, customers cannot easily move applications between AWS and on-premise clouds today. In fact, most users must completely re-write applications to make them work on EC2, and if they later decide to take those workloads off the site, must work hard to convert them to run again on premise. Rackspace has a VMware-driven Private Cloud solution, but it is not compatible with the company’s public cloud, and given Rackspace’s commitment to OpenStack, it will continue to be incompatible in the future. Rackspace also has the challenge of moving all of its own public cloud IaaS and customers under the OpenStack umbrella, if it wants to build a thriving service provider ecosystem.
VMWARE

VMware is the leader in x86 virtualization and virtual infrastructure management, and is leveraging those strengths to take a leading position in the cloud infrastructure market. VMware plays at every level of the cloud market, including IaaS and management (via vSphere, vCloud and vCenter suites, and toolkits such as Go Pro), PaaS (based on Cloud Foundry, which we have not profiled in this report), and SaaS (via VMware Horizon Application Manager).

vSphere is the industry’s leading hypervisor, in terms of maturity, advanced capabilities and market adoption. The vSphere platform provides a broad range of guest operating system support and application support statements, enabling SMBs as well as larger companies to virtualize application workloads and run them with confidence. As we have discussed in this comparative study, VMware provides strong and comprehensive security, business continuity and service-level assurance for business-critical applications, along with an automated IT operations suite for virtual infrastructure management.

VMware then provides SMB-tailored bundles and toolsets to enable users to take advantage of these enterprise-class virtual infrastructure solutions. vSphere Essentials and Acceleration Kits are designed to ease SMB customers’ transition to virtualization, including tools for planning, deploying and managing an initial environment, a range of storage options, and a set of easy-to-use tools to handle day-to-day administrative tasks, such as software patching, asset inventory, scripting and license management with Go Pro.

SMBs often struggle with managing day-to-day IT tasks as their environments grow, due in large part to the absence of automation. VMware’s vCenter Operations Management and vCenter Protect, now included in vSphere Standard with Operations Management Acceleration Kit, create a simplified, integrated and automated approach to IT management across both physical and virtualized environments, including automated operations management, centralized patch management, asset inventory, antivirus, scripting and power management – thus saving IT both time and money.

Next, VMware’s portfolio of end-user computing solutions helps SMBs accelerate successful desktop virtualization initiatives. VMware’s View VDI, ThinApp application virtualization, and Horizon application provisioning and access solutions deliver a personalized high-fidelity user experience at both the virtualized desktop and application layers. SMBs appreciate the simplified integrated management, seamless scalability, and consistent end user experience regardless of target device. Particularly important for SMBs, VMware’s solutions address all the main stumbling blocks in VDI projects including assuring storage performance during “boot storms”, enabling golden image management and virtualization-aware security, and providing a single sign-on end-user catalog for all accessed applications - virtualized, web-based, and SaaS hosted.

The third leg of VMware’s SMB offering is its ecosystem of public cloud infrastructure service providers, which enable SMBs to extend their on-premise infrastructure into the cloud. VMware has differentiated its public cloud infrastructure services from competitive offerings in several ways. The first is VMware vCloud Datacenter Service program, which enables a growing number of VMware certified service providers to deliver enterprise-ready services to SMBs based on VMware vCloud technology. vCloud Datacenter Service Provider partners provide a globally consistent set of vCloud-driven services, along with multi-tiered, enterprise-class SLAs. We examined the vCloud services of Dell, one of VMware’s nine certified vCloud Datacenter Service providers, in an earlier section of this report.
The second differentiator is VMware’s support of open standards like the Open Virtualization Format (OVF) and vCloud API (submitted to the Distributed Management Task Force standards-making body), which together enable workload portability and interoperability across on-premise infrastructure and public clouds. VMware’s third differentiator is vCloud Connector, hybrid cloud technology that allows administrators to deploy and manage VMs and virtual appliances (vApps) from a single pane of glass between off-premise VMware clouds and on-premise vSphere infrastructure. Unlike competitive offerings, vCloud Connector enables users to quickly move applications from internal datacenters to private or public clouds, and back again, removing any potential for lock-in.

**Competitive Advantages**

- VMware is the market leader in virtualization, with proven solutions being used by more than 400,000 customers today, as well as a leader in cloud infrastructure technologies, offering SMB targeted solutions with its vSphere Essentials and Acceleration Kits.
- VMware provides the most secure virtualization and cloud infrastructure, enabled by the vCloud Networking and Security (vCNS) solutions working in conjunction with partner solutions built for the vCNS security framework. Unlike competitive offerings, vCNS is fully integrated into the virtual infrastructure fabric, and delivers security at multiple layers of the cloud IaaS stack, including host, network, application, data and endpoint.
- VMware offers SMBs a broad and flexible portfolio of end-user computing solutions – including VDI and application virtualization offerings – based on its core virtualization platform.
- VMware’s hybrid cloud offering effectively bridges on-premise and off-premise clouds, with enterprise-class enablers such as workload portability and interoperability leveraging common platform, management, and security layers.
- The company has built and nurtured the industry’s largest (and growing) ecosystem of leading cloud service providers, which offer SMBs as well as larger customers services ranging from on-demand, pay-as-you-go IaaS to enterprise-grade hybrid cloud services.

**Competitive Disadvantages**

- VMware Essentials and Essentials Plus Kits provide a strong entry-level virtualization environment for SMBs, but the licenses only cover a limited number of servers. When customers are ready to expand to additional host licenses (along with enhanced functionality), they will need to purchase vSphere Acceleration Kits, which are higher priced though still competitive with Microsoft Hyper-V.
- Fairly or unfairly, VMware has the reputation of being the industry’s “high-priced” virtualization provider, offering good value for enterprises but not necessarily for SMB customers. As this report demonstrates, we believe VMware brings high-value solutions to SMBs at competitive price points. That said, we think VMware has some work to do to educate SMB customers on the strength and value of its solutions.

**MICROSOFT**

Microsoft provides virtualization and management capabilities for on-premise infrastructure, a range of desktop and application virtualization offerings, and a public cloud PaaS solution called Windows Azure (not covered in this report). The company’s virtualization offering is based on Hyper-V (offered either standalone or as part of Windows Server), and its management offering is based on a range of Microsoft System Center modules. Hyper-V 3 is expected to become available in September 2012, though customers will not have an opportunity to take full advantage of its new features and capabilities until the GA release of Microsoft System Center 2012 SP1, which is not expected until late 2012 or early 2013. Microsoft has the second largest share and presence in the virtualization market,
trailing only VMware, and the company's offerings are particularly suited to large Microsoft Windows customers.

But the company's Hyper-V + System Center VMM platform is lacking in virtualization and cloud infrastructure capabilities, in areas such as security, business continuity, and storage management. For example, Hyper-V 3 does not provide virtualization-aware security, such as VMware does with vCloud Networking and Security, nor does Hyper-V 3 offer a centralized network security management solution. Hyper-V is based on a Windows OS-dependent architecture, which results in a much larger footprint, attack surface area, and the associated need for Windows patching. In terms of business continuity features, Hyper-V 3 does not offer a fault tolerance solution to match vSphere’s FT capability. Hyper-V 3 is also missing advanced storage management features, such as automated storage workload balancing capabilities (like those of Storage DRS) and storage I/O controls to ensure that critical applications can meet quality of service commitments. In contrast, VMware’s virtualization platform provides all of these features and capabilities to reduce downtime and maintain SLAs in on-premise and off-premise infrastructures.

Despite (or perhaps because of) providing the most prevalent operating systems on the planet in the various versions of Windows, Microsoft lags in desktop virtualization. For many years Microsoft relied on a partnership with Citrix in this space and in proffering virtualization features in the OS like terminal services (now Remote Desktop Services). Now with Hyper-V they’ve started offering their own VDI and application virtualization solutions, but because they are narrowly focused on pure Microsoft stacks (servers, desktops and applications) and don’t provide key features like linking and cloning or virtualization-aware security, these solutions have often been limited to small deployments and test and dev types of environments. In Windows Server with Hyper-V there are signs of advancement with dynamic memory features and an enhanced user experience with remote graphics support, but management and operations of VDI at increasing scale is challenging. Microsoft does provide App-V for application virtualization, RDS for session virtualization, and User Experience Virtualization for persisting roaming user profiles, all of which can be leveraged in other vendor desktop virtualization schemes. It's expected that the upcoming Hyper-V 3, SCVMM 2012, and other impending releases will advance Microsoft's offerings in this area.

Though Microsoft claims to provide hybrid cloud capabilities, the story is well out in front of reality, since a Microsoft-enabled hybrid cloud just isn't possible today. In particular, there is currently a significant disconnect between Microsoft’s on-premise virtualization infrastructure and public cloud. Users have found it difficult to move their on-premise workloads to Windows Azure, and next to impossible to move them out of Azure later on. Microsoft is hoping to address this issue in the future by introducing a new set of IaaS capabilities for its public Azure cloud, which among other things, would allow persistent VMs running Windows or Linux applications to move between on-premise infrastructure and Azure. This capability is dependent on yet-to-be-released SCVMM 2012 technology, and is only part of a non-production preview release of Azure today. Microsoft also does not offer cross-cloud interoperability and management capabilities, such as those offered in VMware vCloud Director and Connector.

**Competitive Advantages**

- Microsoft is now playing at nearly every level of the cloud market, including IaaS, PaaS, and SaaS offerings, and is investing considerable money and effort to brand itself as a cloud leader to business customers. The company has announced its intention to become a leading hybrid cloud supplier.
- Microsoft is investing heavily in training, equipping, and motivating its vast array of channel partners to win in cloud opportunities. The company is providing specific partner incentives to accelerate adoption of MS cloud technologies.
• Microsoft is pursuing a cross-hypervisor strategy that may appeal to some customers.

**Competitive Disadvantages**

• Microsoft is lagging in virtualization and cloud infrastructure capabilities. Though Hyper-V 3 will address some of the current deficiencies, customers will not be able to fully utilize all of the new Hyper-V 3 features until System Center 2012 SP1 is released into production, which is not expected until late 2012 or early 2013. Even then, Hyper-V 3 will remain unproven until it establishes a track record with customers.

• Microsoft’s Hyper-V platform is a distant second in the virtualization market, and though it has gained some market traction over the past year, it still trails vSphere by a significant amount.

• Microsoft’s ability to bring new and enhanced virtualization and cloud offerings to market is still architecturally tied to its multi-year Windows Server and System Center release cycles, which will make it quite difficult for Microsoft to become an innovator in this space.

• Though Microsoft is currently investing in channel development, many partners are quite worried about the likelihood of channel conflict, which could very well result in Microsoft taking business and the customer relationship away from them.

• Microsoft has very limited uptake of Hyper-V and System Center among service providers, given the company’s lack of IaaS capabilities and providers’ reluctance to partner with a company that might compete directly with them in the public cloud.

• Existing and would-be Microsoft customers are concerned about the potential for lock-in to the proprietary elements of Microsoft’s cloud offerings.

**CITRIX**

Citrix provides SMBs with server virtualization and end user computing solutions (which are the focus of this comparative study), and is also developing a cloud portfolio that will include both IaaS and PaaS offerings. Citrix’s market coverage has grown dramatically in recent years, from a primary focus on server-based multi-user computing just ten years ago, to a diversified set of virtualization, cloud, collaboration and networking solutions today. Citrix has been a technology partner with Microsoft since the mid-1990’s, and in recent years that relationship has expanded to include some reciprocal sales and joint marketing efforts.

Citrix XenServer 6.0 is the company’s current server virtualization offering for SMBs. Based on the open-source Xen hypervisor, Citrix XenServer itself was open sourced in late 2009, though Citrix still licenses advanced versions of the product, including XenCenter management. Citrix certainly views server virtualization as an important enabling technology in the context of its broader strategy, but we question how much Citrix will prioritize XenServer in its R&D investments going forward, especially given Citrix’s support of Hyper-V in its own customer environments, where Citrix desktop and application virtualization solutions are deployed. With a minor update release scheduled for later in 2012, Citrix is demonstrating at least a short-term commitment to continuing to enhance the XenServer product. Compared to vSphere, XenServer has relatively limited use today in supporting production applications among SMB and enterprise customers.

The current version of XenServer has basic virtualization functionality that an SMB customer will be looking for, including high availability, live VM migration, and automated VM workload placement and balancing, but it does not include a number of advanced capabilities offered in vSphere. For example, XenServer still lacks a thin hypervisor footprint, as well as a storage live migration capability. Also lacking are storage and network I/O controls, to ensure that the most important virtual machines get adequate I/O resources even in times of congestion. Citrix offers a set of security best practices for virtual server hosts and guests, as well as legacy physical security tools, but XenServer does
not provide virtualization-aware security features such as virtual/logical firewalls between VMs, to protect from network-based threats. XenCenter delivers basic resource monitoring capabilities, but it lacks a number of the management features included in VMware vCenter Operations Manager. Finally, relative to vSphere, XenServer provides SMBs with only a partial set of virtualization planning and deployment tools.

Citrix has a long and distinguished history with a wide portfolio of desktop virtualization solutions, but Citrix’s SMB strategy for desktop virtualization is based on their acquisition of Kaviza and the VDI-in-a-Box solution. This substituted for XenDesktop in the SMB domain, providing a much simpler to manage, VDI software appliance. While XenDesktop was clearly too complicated and involved for many SMB organizations to manage and operate, VDI-in-a-Box is perhaps too constrained for growing SMBs, since it’s missing key features like virtualization-aware security, and there is no technical upgrade path. XenApp was considered in this report as the application virtualization comparison to VMware’s ThinApp, but SMBs will be challenged to separately deploy and manage the relatively heavy-weight XenApp if they’ve opted for VDI-in-a-Box. In addition, while VDI-in-a-Box presents some storage features to help SMBs theoretically avoid investing in centralized storage for base desktop images, Citrix still recommends centralized storage for backups and user/application data. Citrix Receiver can provide a single sign-on to virtual desktops and applications, web and SaaS apps, and even App-V, but is limited to an on-premise version – unlike VMware’s Horizon, whose hosted version may be more attractive to SMBs.

Though we have not formally assessed Citrix public cloud infrastructure offerings in this report, we believe SMBs should at least be aware of Citrix’s initiatives in this area. Citrix’s still developing public cloud IaaS is based on CloudStack technology, which the company purchased in mid-2011. Earlier this year, Citrix moved the focus of CloudStack innovation away from OpenStack when it contributed its entire CloudStack source code to the Apache Software Foundation. The CloudStack service provider ecosystem is still in the very early stages of development, and doesn’t have much to offer SMBs today, but we expect that the ecosystem will develop significantly over the coming year.

**Competitive Advantages**

- Citrix is one of the leading vendors in end-user computing, including a broad portfolio of desktop and mobile virtualization technologies that are now tied into the cloud.
- Citrix has a strong presence and large installed base among SMB customers, with its traditional server-centric multi-user computing (aka session virtualization) offerings (now part of XenApp, but formerly under the MetaFrame brand).
- XenServer and the underlying Xen hypervisor benefit from the innovation of the open source developer community, although Xen has fallen somewhat out of favor in the open source community.
- Xen has a leading market share among open-source hypervisors.

**Competitive Disadvantages**

- Citrix has de-emphasized XenServer as a commercial offering over the past couple of years, though it continues to invest in enhancing the product.
- Citrix is a distant third in terms of market share and presence in the server virtualization space, and therefore XenServer may not be regarded by some SMB customers as a safe or comfortable choice.
- Citrix XenServer lags VMware vSphere in a number of functional areas, including security, virtual infrastructure management, and quality of service controls.
- XenDesktop is too expensive for most SMBs, so they are forced to buy the much less functional VDI-in-a-Box solution instead.
RED HAT

Red Hat’s virtualization offering is based on Red Hat Enterprise Virtualization (RHEV), a relative newcomer among major hypervisor offerings, having first come to market in 2009. Though RHEV is based on the open-source KVM distribution, Red Hat provides substantial value-added functionality in its commercial version of the technology. Red Hat regularly releases enhanced versions of RHEV, though of the four leading hypervisors, the platform has the smallest adoption rate among SMB customers. RHEV-M, the management component of RHEV, is built on Red Hat Enterprise Linux (RHEL), which SMB customers must license for an additional annual fee.

The current version of RHEV has basic virtualization functionality that an SMB customer will be looking for, including a hypervisor (RHEV-H), bare metal hypervisor deployment, high availability, live VM migration, optimized guest drivers, and advanced memory management support, but it does not include a number of advanced capabilities offered in vSphere. For example, RHEV supports a relatively small number of guest OSs, limited today to major Windows versions and RHEL. RHEV still lacks storage load balancing, as well as a storage live migration capability. RHEV does not support snapshots of live (running) VMs, nor does it enable administrators to “hot add” resources to running VMs. Also lacking are storage and network I/O controls, to ensure that the most important virtual machines get adequate I/O resources even in times of congestion. Red Hat offers some Red Hat Enterprise Linux security features for virtual server guests, as well as legacy physical security tools, but RHEV does not provide virtualization-aware security features such as application firewalls between VMs, to protect from network-based threats. RHEV-M delivers basic resource monitoring capabilities, but it lacks a number of the management features included in VMware vCenter Operations Manager. Finally, relative to vSphere, RHEV provides SMBs with only a partial set of virtualization planning and deployment tools.

RHEV is often positioned as a hypervisor that works well alongside VMware, and it has gained some traction in vSphere environments. However, RHEV typically is not used to support production workloads.

Red Hat is also building a set of cloud offerings, including its own OpenStack cloud IaaS distribution and CloudForms hybrid cloud management platform, but these offerings have been in transition and are not candidates today for public cloud infrastructure.

**Competitive Advantages**

- Red Hat Enterprise Virtualization (RHEV) has come a long way in the past couple of years, and now has some of the features and capabilities of VMware vSphere.
- As a master packager and aggregator of many open source software initiatives, Red Hat benefits greatly from the rapid innovation and leveraging effect of its partner ecosystem, making it a highly agile and nimble player among virtualization and cloud technology providers.
- Red Hat’s virtualization and cloud offerings tend to be based on open standards and are priced very competitively, which gives many IT buyers greater confidence that they can avoid lock-in and higher costs down the road.

**Competitive Disadvantages**

- RHEV is the least mature of the four major hypervisors, and has the least adoption among SMB customers.
- RHEV supports a relatively small number of guest OSs, limited today to major Windows OS versions and RHEL.
- RHEV lags VMware vSphere in a number of functional areas, including security, virtual infrastructure management, and quality of service controls.
- Red Hat has wavered in its cloud strategy over the past few years, only recently deciding to build its own OpenStack cloud IaaS distribution. As a result, Red Hat has lost ground to other major cloud technology vendors in developing public cloud infrastructure that might become the basis for a hybrid cloud offering down the road.

**AMAZON**

Amazon provides public cloud infrastructure-as-a-service offerings, based on its Amazon Web Services (AWS) platform. The company is a pioneer in commodity cloud computing and has the largest market share among public cloud providers, with six years’ experience in delivering cloud compute services.

AWS EC2 compute, Elastic Block Store (EBS) and Simple Storage Service (S3) have traditionally been focused primarily on developers, who value the ease of use, simple credit-card billing and overall productivity of the AWS environment. But we believe AWS is increasingly being used by SMBs as well as research and educational institutions, which value the simplicity, flexibility and pay-as-you-go business model for hosting and running non-critical applications on EC2 infrastructure.

In fact, Amazon has recently taken steps to make AWS more attractive to businesses, which have justifiably been hesitant to put their applications and data into a commodity public cloud. For one, Amazon recently announced a partnership with Eucalyptus, an open-source cloud player that has been offering EC2 compatibility for its private clouds. This could eventually provide Amazon with a credible offering for both private and hybrid clouds. Second, Amazon unveiled the AWS Storage Gateway, which enables businesses to connect their on-premise infrastructure to AWS storage, via a software appliance provided by Amazon. AWS is positioning this solution to address several key use cases, including rapid data backup and recovery, cloud-based DR, and cloud-bursting (enabled by allowing users to mirror their on-premise data to EC2 instances). Third, Amazon announced a beta of AWS Simple Workflow Service (SWF), which allows businesses to more easily build, execute and manage multi-faceted, process-oriented applications.

Another use case AWS has succeeded in addressing is in providing on-demand, hyper scale-out of homogeneous virtual server resources. AWS provides the largest pool of public cloud computing capacity in the industry, which makes it a good fit for “spiky” modeling and simulation workloads and some HPC applications.

EC2 instances can take advantage of AWS functionality such as auto-scaling, load balancing, and cloud monitoring services. AWS CloudFormation eases provisioning by allowing users to create a collection of related AWS resources, describe them in a template, and then provision them without having to worry about underlying dependencies. Amazon CloudWatch provides visibility into the operational health, resource utilization, and application performance of each EC2 instance. Amazon also offers a series of security services, including AWS Identity and Access Management (IAM). Though AWS security and management capabilities are not enterprise class, they are more than sufficient for a majority of Amazon’s user base.

The AWS Virtual Private Cloud (VPC) offering, which is now supported for production use, enables users to provision AWS virtual servers in a user-defined virtual IP network. This allows companies to do things like create a public-facing subnet for web servers but keep their database or application servers in a private-facing subnet with no Internet access. Customers can also connect on-premise infrastructure to private and isolated AWS compute resources via a VPN connection, and extend existing security (firewalls, IDS) and management to those resources. Although many companies will
find this capability useful, the VPC still runs on AWS infrastructure, which does not give it the level of high availability, security and layer 2 isolation that most enterprise users demand for their applications.

The AWS partner ecosystem consists of a community of Independent Software Vendors (ISVs) and Systems Integrators (SIs) that build and offer services and solutions on the Amazon public cloud. The ecosystem is strong – many software tools and application vendors (including some of the world’s largest) have licensed and packaged their software to run on EC2, easing overall deployment for customers. Amazon provides developers with full API access to the AWS infrastructure.

On the flip side, AWS has a weak cloud compute SLA, even among public cloud providers. AWS offers a 99.95% availability commitment, evaluated over a 1-year term, with maximum service credits at 10% of a customer’s bill in the event of service disruption. It is important to note that Amazon’s definition of “service availability” is not a typical enterprise uptime SLA definition: it is defined as the ability to launch new EC2 virtual server instances in a specific availability zone. Amazon expressly does not guarantee the continued uptime of any virtual server once it is running, nor any specific performance metrics.

As a result, AWS’ highly publicized multi-day outage in 2011 did not violate Amazon’s definition of “availability”, even though tens of thousands of customers were down for several days. Furthermore, it is the user’s responsibility to re-start any VM that is halted due to planned or unplanned outages. While these SLA terms might be acceptable to most developers, the multi-day AWS outages, which took several prominent websites offline, underscore the risk of running applications on Amazon.

**Competitive Advantages**

- Amazon is the pioneer in public cloud computing, and AWS has by far the largest public cloud IaaS market share and brand presence.
- The company provides a large portfolio of Amazon-developed IaaS products and services, which simplify use cases such as dev/test and cloud-bursting of workloads during peak demand periods.
- A rich ecosystem of third party software has developed around AWS, including a large stable of popular software tools and applications (including selected Oracle and SAP software) that have been licensed, packaged, and certified to run (mostly as SaaS) on EC2.
- The EC2 cloud has strong appeal for developers, due to its vast array of tools and APIs, exceptional ease of use, low pricing, and quick time-to-deployment.
- Amazon’s relationship with Eucalyptus might eventually enable AWS to provide users with an Amazon EC2-compatible private cloud, based on-premise or off-premise, as well as a hybrid cloud solution.

**Competitive Disadvantages**

- Amazon’s offering remains developer centric, rather than business or enterprise focused. The company does not have a field sales and solutions engineering function to interact with corporate clients. Two classes of technical support services are now available: no-frills, free of charge; and a paid service, but it is unclear how many customers (especially non-developers) are taking advantage of these services.
- AWS has a weak cloud compute SLA, even among public cloud providers. AWS does not offer SLA terms for the uptime of virtual servers, nor does it provide guaranteed allocations of compute, storage and networking resources to ensure quality-of-service levels for users’ applications.
- Business and corporate customers generally have to re-architect their existing (“legacy”) applications to run them in the Amazon EC2 cloud. This can take considerable effort, and once
applications have been adapted to run on EC2, they are no longer portable to on-premise infrastructure or other clouds.

- Though Amazon does provide a Virtual Private Cloud (VPC), the VPC still runs on AWS infrastructure, and therefore does not offer true hybrid (compatible on-premise and off-premise) cloud capabilities. AWS does not provide the option for an on-premise private cloud today.

**RACKSPACE**

Rackspace is the second largest provider of public cloud computing services, behind Amazon, and the largest provider of managed hosting services. Rackspace provides IaaS in a public, hosted cloud (Cloud Servers), with or without managed services. The company also provides cloud-hosted storage (Cloud Files), Cloud Load Balancers, and a PaaS offering (Cloud Sites, which is not covered in this report). Rackspace recently began to merge its cloud IaaS with managed hosting services, with the result that customers can now select a managed service level for Cloud Servers, which is over and above the SLA terms provided in the baseline offering.

Rackspace public Cloud Servers offers Xen-based virtual server migration capabilities, as well as load balancing via Cloud Load Balancers (for a small additional charge). Rackspace acquired Cloudkick in late 2010, which provides RESTful APIs and plug-ins to enable server monitoring and management across multiple providers from a single dashboard. The service was recently re-named Rackspace Cloud Monitoring, and continues to be sold as a standalone service. In addition, Rackspace is now offering managed services that provide monitoring of servers and cloud instances, with rapid response and resolution of issues.

While Rackspace has worked hard over the past few years to strengthen its cloud infrastructure and services, the cloud IaaS is still not enterprise class. Rackspace lacks the broad feature set of Amazon AWS and the enterprise capabilities of VMware vCloud. To help close this gap, Rackspace is open sourcing its cloud development under the OpenStack initiative. Rackspace will provide its own set of APIs, rather than offering an AWS API. Rackspace is counting on creating an ecosystem that will accelerate the development of more advanced IaaS and management capabilities, to help bring its public cloud closer to feature parity with Amazon.

The Rackspace SLA includes 100% uptime guarantees for the network and data center (excluding scheduled maintenance), a maximum of 1 hour of downtime on unplanned server outages, and twice daily snapshots of virtual server images for backup, along with 24x7 chat/phone support. The premium managed service level adds in server OS and apps patching/updating, 24x7 monitoring response and resolution, and more personalized technical support. Rackspace is well regarded in the industry for its proactive, high-touch service and support (which it brands as “Fanatical Support”).

In addition to its public IaaS offering, the company provides a Rackspace Private Cloud, running on dedicated servers with VMware vSphere virtualization. Workloads cannot be freely moved today across Rackspace public Cloud Servers and Rackspace Private Clouds, so this is not a true hybrid cloud solution.

Today, the OpenStack community includes more than 180 corporate members, including companies and service providers looking to deploy large-scale cloud deployments for private or public clouds by leveraging an open-source ecosystem.

From what we’ve observed, Rackspace tends to appeal to small and mid-sized businesses as well as larger companies hosting less critical, web-centric applications. Rackspace competes on the basis of its strong support and managed hosting capabilities, and on the strength of the rapidly growing, open standards-based, OpenStack ecosystem.
Competitive Advantages

- Rackspace is a leading provider of managed hosting services, and is beginning to incorporate these into its cloud offerings to increase its competitive differentiation.
- Rackspace is highly regarded in the industry for its personalized, high-quality customer support and service, which is brands as “Fanatical Support”.
- Rackspace’s participation in the OpenStack initiative will help build a robust ecosystem for its cloud offerings, and will likely help strengthen its cloud IaaS and management capabilities.

Competitive Disadvantages

- Rackspace does not provide enterprise-class IaaS functionality today, and its self-management capabilities are particularly weak.
- Rackspace offers a single-tier SLA, with terms that are stronger than Amazon’s but still not enterprise-class.
- OpenStack will be competing for mindshare in the open-source community with Red Hat’s open source offerings.
- Rackspace tends to be most proficient at handling Web-centric application environments, versus traditional enterprise applications like ERM and SCM suites.
- The company does not provide a true hybrid cloud solution. While Rackspace has a reasonably strong public IaaS cloud, and a separate private cloud based on VMware, workloads cannot be easily moved between these environments.