26 November 2007
Americas/United States
Equity Research
Software / Computer Hardware (Software & Services/IT Hardware) /
OVERWEIGHT/MARKET WEIGHT

Desktop Virtualization Comes Of Age

Research Analysts

Philip Winslow, CFA
212 325 6157
philip.winslow@credit-suisse.com

Robert Semple, CFA
212 538 2828
robert.semple@credit-suisse.com

Jason Maynard
415 836 6353
jason.maynard@credit-suisse.com

Dennis Simson
212 325 0930
dennis.simson@credit-suisse.com

Bryan McGrath
415 836 6373
bryan.mcgrath@credit-suisse.com

THEME

The Data Center Is The Desktop

Desktop Virtualization Has Been Underappreciated. While much of Wall Street has become fixated on the growth potential of server virtualization, we believe that investors have underestimated the size and potential growth of the desktop virtualization market. We expect desktop virtualization software to grow from minimal deployments currently to at least a $1.5 billion market by 2011 with approximately 25.6 million end users—representing 5.7% of the professional desktop PC installed base.

Desktop Computing = Serial Cost Offender. In the current spending environment of IT organizations looking to reduce the cost of maintaining existing IT systems, the corporate desktop is a serial cost offender. Desktop hardware and software acquisition expenditures typically account for only 20-30% of the total cost of the device, while the remaining 70-80% consists of IT maintenance. We estimate that desktop virtualization could lower the annual total cost of ownership of desktop computing by 40-50% versus high-end workstations and 5-10% versus low-end PCs, while simultaneously improving computing flexibility and reliability for end users.

Why Now? "Thin" computing models have failed to gain significant traction in the past, as the static published desktops of legacy thin-client architectures could not satisfy the desktop needs of all users—many of whom required more performance, data isolation, desktop personalization, and control. Furthermore, many applications are not designed for use in a multi-user terminal services environment, which limited the addressable user base of the traditional server-based computing model. Now, however, we believe that virtualization technologies have matured to the point where they can now be applied to the corporate desktop environment to improve performance, increase flexibility, provide personalization, remove application compatibility issues, and reduce operating and capital expenses.

How To Invest In Desktop Virtualization: Citrix Systems. While we expect both Citrix Systems and VMware to attempt to leverage dominant positions in each company's respective core virtualization market to enter into the desktop virtualization market, we view Citrix Systems as the better-positioned vendor to capitalize on this emerging opportunity, based on the breadth and depth of its product portfolio, as well as its large installed base of more than 70 million end users currently utilizing Presentation Server. Furthermore, we expect IT hardware vendors to experience a shift in spending from traditional desktops to thin-clients and higher-end servers, where we believe that Hewlett-Packard has developed the strongest roadmap.

Table Of Contents

Executive Summary

The Problem: The Cost And Inflexibility Of Desktop Management

Twenty-five years have passed since IBM launched its version of the personal computer, and since this time, the desktop PC has been the mainstay of the desktop service delivery environment. However, managers across all industries have recently found the existing PC infrastructure to be unsustainable—both from a cost and a scalability perspective.[1] What began as a useful tool that boosted productivity has grown into a bloated device requiring constant upgrades and maintenance due to compatibility issues associated with patches, new hardware, and software releases.

Macro level business requirements are driving a fundamental re-addressing of IT strategy with the focus on cost and efficiency. The high cost and high manpower requirements to maintain the "Fat PC" network through manual installations of applications and patches directly on users' computers prompted organizations to consider other ways of delivering application access to end users—including automated software distribution, server-based computing, application streaming, etc.[2,3]

While information technology budget growth has been constrained over the past several years, budgetary dollars spent on maintenance of corporate systems continues to grow unabated. In fact, the majority of IT spending is now deployed for just "keeping the lights on." An estimated 75-80% of the IT budget is spent on supporting existing IT investments, leaving a dwindling amount of funds available for strategic initiatives. As such, IT organizations must first reduce the cost of owning and maintaining technology systems in order to eventually re-deploy those funds to business-enabling IT projects.

Given this backdrop of increasing maintenance costs, the corporate desktop is a serial cost offender, as desktop hardware and software acquisition costs typically account for only 20-30% of the total cost to the customer over the life of the device, while the remaining 70-80% consists of IT maintenance costs, such as moves/add/changes (MACs) of employees, repairs and fixes, and upgrades.[1] According to a Gartner Research study, the 5-year TCO for a PC averages more than 10 times the original purchase price. Furthermore, inside of large enterprises, server utilization levels range from 15-30%—a level of inefficiency that has driven many organizations to purchase and deploy software solutions that enable server virtualization and consolidation (e.g., VMware). In comparison, average resource utilization rates for PCs have been estimated at less than 5%.[5]

According to a Gartner Research study, the 5-year TCO for a PC averages more than 10 times the original purchase price.

The Solution: Desktop Virtualization Trumps Legacy "Thin" Computing Technologies

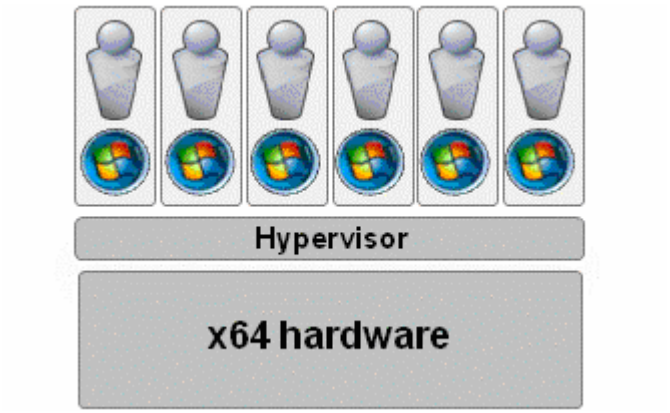
In our opinion, enterprises will increase their relative spending on infrastructure solutions that 1) improve performance and flexibility, 2) reduce the overall cost of owning desktops, and 3) provide for secure but "accessible" computing environments. Although "thin" computing models have failed to gain significant traction in the past, we believe that virtualization technologies have matured to the point where they can now be applied to the corporate desktop environment to improve performance, increase flexibility, and reduce operating and capital expenses—just as virtualization technologies have been increasingly deployed to improve the performance and cost efficiencies in data centers' server environments.

Desktop virtualization entails building a large server and dividing the system—utilizing Microsoft, VMware, or Xen hypervisor technologies and machine virtualization management tools—into multiple virtual machines each running the Windows desktop operating system. (See Exhibit 10.) Complete desktop environments, including operating system, applications, and configurations, reside in the virtual machines, and end users use

remote display software to access their desktop running on the backend server from a PC or thin-client.[6] We estimate that virtual desktops could lower the annual total cost of ownership of desktop computing by 40-50% versus high-end workstations and 5-10% versus low-end PCs—while simultaneously creating improved computing flexibility and reliability for end users.

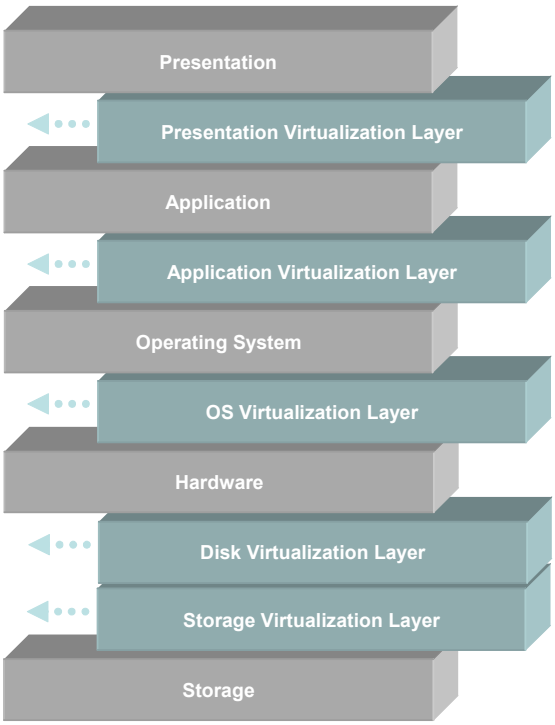
Furthermore, as desktop virtualization technology evolves, we believe that the concept of utility computing and, more specifically, the use of multiple virtualization technologies (i.e., in addition to the operating system virtualization layer via a hypervisor) can be applied to the corporate desktop environment to improve performance, increase flexibility, and reduce operating and capital expenses. In our opinion, combining virtualization technologies, which have historically been utilized independently for desktop management, to separate the four primary components of the traditional desktop infrastructure "stack"—the disk, operating system, application, and presentation layers—can produce a Virtual Desktop Utility (VDU) that parallels the theme of utility computing and enhances the advantages of desktop virtualization. (See Exhibit 2.) Built upon desktop virtualization as a foundation, a Virtual Desktop Utility then incorporates functionality from other desktop management tools to offer many of the individual advantages of the legacy models, which we describe in detail in the Desktop Management Models section of this report, in one, consolidated desktop delivery platform.

Exhibit 1: Virtual Desktop Architecture



Source: Citrix Systems

Exhibit 2: Computing Stack And Virtualization Layers



Source: Citrix Systems

The Timing (Why Now?): Virtualization Technologies Have Matured And Server Scalability Has Increased

In the late 1990s, the proposed movement to thin-client terminals and server-based computing was founded on the basis of lowering the total cost of ownership of the end user's device through lower hardware and management costs. While the underlying cost savings and simplified management principles of thin computing were aligned with IT departments' goals, the standardized published desktops of traditional server-based

computing architectures provided by companies such as Microsoft and Citrix Systems could not satisfy the desktop needs of all users—many of whom required more performance, data isolation, desktop personalization, and control.[7] As such, widespread adoption of hosted desktops and thin-client computing has remained limited. However, with the current desktop management environment suffering from the aforementioned challenges, we believe that IT organizations—especially large enterprises—are seeking new technologies to reduce the cost and complexity of traditional PC management.

While "thin" computing models failed to gain significant traction in the past, we believe that the maturation of virtualization technologies, combined with the growing management costs of corporate desktops, as well as the increased end user hardware systems costs and potential for application conflicts associated with Windows Vista, positions desktop virtualization at an inflection point ahead of significantly greater adoption and growth over the next one to two years than in past. Virtual desktops can save customized user preferences and application configurations, replicating the current desktop environment of many knowledge workers—thereby broadening the addressable user base and appeal of desktop virtualization versus legacy thin computing models.

While "thin" computing models failed to gain significant traction in the past, we believe that the maturation of virtualization technologies, combined with the growing management costs of corporate desktops, as well as the increased end user hardware systems costs and potential for application conflicts associated with Windows Vista, positions desktop virtualization at an inflection point ahead of significantly greater adoption and growth over the next one to two years than in past.

In addition to maturing virtualization software technologies, another significant change in the IT landscape that has increased the viability of desktop virtualization is the release of the latest generation of servers using dual-core and quad-core processors, which can easily handle a desktop-to-server ratio up to 30:1. Desktop virtualization thereby enables IT departments to consolidate management of many physical desktops onto a single server, which dramatically increases the effectiveness of storage, management tools, and virtualization capabilities and lowers the cost per user. As a result of the maturation and growing acceptance of virtualization technologies, combined with improved server hardware systems, desktop virtualization is now becoming part of many companies' desktop replacement strategies.[8]

The Opportunity: A Multi-billion Dollar Software Market

Within the long-term theme of changing existing desktop delivery paradigms, presentation virtualization software represents a relatively mature market comparatively speaking, but we believe that the desktop virtualization software market is positioned at the very beginning of a high-growth period. Specifically, the presentation virtualization software market is forecasted to grow from $1.225 billion in 2006 to $2.193 billion in 2011, representing a compound annual growth rate of 12.4%. In comparison, the desktop virtualization market is expected to grow at a compound annual rate of 87.9% over the next five years—reaching $1.500 billion in 2011. (See Exhibit 3.)

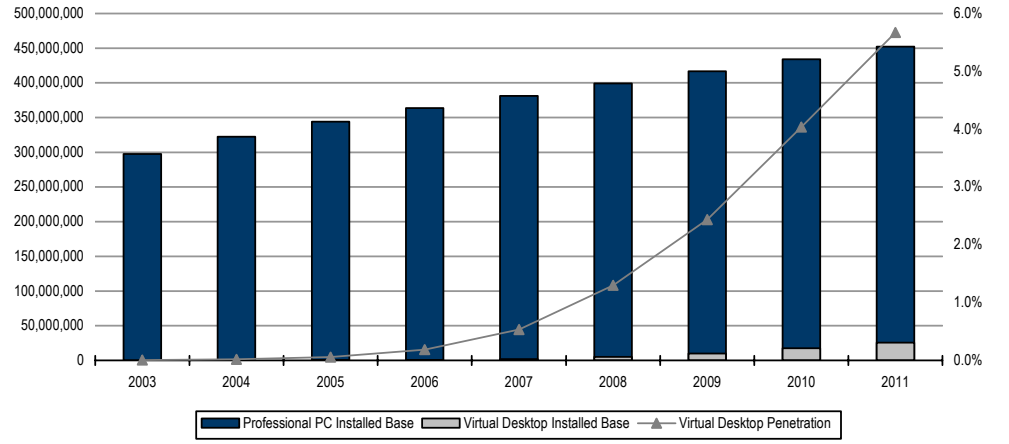
Exhibit 3: Virtualization Software Forecast
US$ in millions, unless otherwise stated

	2003	2004	2005	2006	2007	2008	2009	2010	2011	CAGR (%) 2006-2011
Application Virtualization	3.8	12.0	20.0	35.0	55.0	80.0	110.0	150.0	200.0	41.7%
year-over-year growth		*215.8%*	*66.7%*	*75.0%*	*57.1%*	*45.5%*	*37.5%*	*36.4%*	*33.3%*	
Desktop Virtualization	2.3	5.8	19.0	64.0	182.0	440.0	750.0	1,190.0	1,500.0	87.9%
year-over-year growth		*152.2%*	*227.6%*	*236.8%*	*184.4%*	*141.8%*	*70.5%*	*58.7%*	*26.1%*	
PC Disk Virtualization	1.0	2.5	6.0	11.0	18.0	60.0	100.0	160.0	233.0	84.2%
year-over-year growth		*150.0%*	*140.0%*	*83.3%*	*63.6%*	*233.3%*	*66.7%*	*60.0%*	*45.6%*	
Presentation Virtualization	959.0	1,059.7	1,137.8	1,225.0	1,372.0	1,554.0	1,762.0	1,976.0	2,193.4	12.4%
year-over-year growth		*10.5%*	*7.4%*	*7.7%*	*12.0%*	*13.3%*	*13.4%*	*12.1%*	*11.0%*	
Server Virtualization	205.0	560.5	819.0	1,033.7	1,366.6	1,854.6	2,506.8	3,047.2	3,412.1	27.0%
year-over-year growth		*173.4%*	*46.1%*	*26.2%*	*32.2%*	*35.7%*	*35.2%*	*21.6%*	*12.0%*	
Virtualization	**$1,171.1**	**$1,640.5**	**$2,001.8**	**$2,368.7**	**$2,993.6**	**$3,988.6**	**$5,228.8**	**$6,523.2**	**$7,538.5**	**26.1%**
year-over-year growth		***40.1%***	***22.0%***	***18.3%***	***26.4%***	***33.2%***	***31.1%***	***24.8%***	***15.6%***	

Source: IDC, Credit Suisse estimates.

Given that the installed base of professional desktop PCs is forecasted to grow to 452.1 million in 2011, we estimate that a desktop virtualization software market reaching $1.5 billion in revenue by 2011 would translate into an installed base of approximately 25.6 million virtual desktops—representing approximately 5.7% penetration of the professional desktop PC installed base in five years, which we view as very achievable given the cost savings and improved performance and flexibility of this desktop delivery model. (See Exhibit 4.)

Exhibit 4: Professional Desktop PC Versus Virtual Desktop Installed Bases – Implied By Desktop Virtualization Software Market Forecast In Exhibit 3



Source: IDC, Gartner, Credit Suisse estimates.

Therefore, while much of Wall Street has become fixated on the growth potential of the server virtualization market, we believe that desktop virtualization solutions are poised for significant growth and represent an end market that could eventually surpass server virtualization software, given the relatively low penetration levels that resulted from this market sizing analysis.

The Desktop Virtualization Winners: Broadest Portfolios Of Desktop Delivery Solutions Triumph

From a stock perspective in the software industry, we view Citrix Systems followed by VMware as the vendors most likely to benefit from increased adoption of server-based and virtual desktop technologies. The desktop virtualization market represents the combination of many of the underlying technologies of both presentation and server operating system virtualization software solutions, and Citrix Systems and VMware maintain the vast majority of the market share of these two sub-segments of virtualization software—with Citrix Systems dominating the presentation virtualization market and VMware dominating the server virtualization market.

The desktop virtualization market represents the combination of many of the underlying technologies of both presentation and server operating system virtualization software solutions, and Citrix Systems and VMware maintain the vast majority of the market share of these two sub-segments of virtualization software—with Citrix Systems dominating the presentation virtualization market and VMware dominating the server virtualization market.

Although our vision of a Virtual Desktop Utility (VDU), as well as desktop virtualization in general, offer many advantages compared to other desktop management models, some disadvantages may exist to desktop virtualization relative to other desktop delivery architectures depending on the end user type (e.g., power user vs. knowledge worker vs. administrative vs. mobile worker, etc.). For example, 50 to 60 published desktops (e.g., via Presentation Server) can be run on a 4-way IBM LS20 blade (32 bit) with 4-8 GB memory at a hardware cost of approximately $6,000, while 25 to 30 virtual desktops can operate on an 8-way C-Class HP blade (32 bit) with 32 GB memory at a hardware cost of approximately $22,000. If an end user does not require the personalization and performance of a virtual desktop (e.g., an administrative worker), a more-static published desktop might be more cost effective for the user, given that the hardware cost of published desktops at $100-120 per user is far less than $733-800 per virtual desktop user.

As such, selecting one option over another (or employing a combination) is based on a combination of both user and IT needs/requirements. Based on these dynamics, while desktop virtualization represents, in our opinion, the most compelling form of desktop delivery and management that most closely resembles the traditional PC experienced from an end user experience perspective, we expect a "mixed environment" to exist—even within organizations utilizing virtual desktop technologies.

Based on these factors, while we expect both Citrix Systems and VMware to attempt to leverage their relative dominant positions in each company's respective core virtualization markets to enter into the desktop virtualization market, we believe that the software vendor offering the broadest, yet most-integrated set of desktop delivery solutions will ultimately be best-positioned to lead this emerging market.

Ultimately, we view Citrix Systems the vendor best-positioned to capitalize on the emerging desktop virtualization market, based on the breadth and depth of its extensive application and desktop delivery product portfolio, as well as the installed base of organizations currently deploying Presentation Server. More than 70 million end users already utilize Presentation Server to run applications on a central terminal server and then provide end users with desktop access to that server, and we believe that the company's soon-to-be-released Citrix XenDesktop solution will represent the most feature-rich desktop virtualization software on the market that also most closely parallels the Virtual Desktop Utility model.

- *Citrix Systems*. Given the breadth and depth of its extensive application and desktop delivery product portfolio (including the soon-to-be-released Citrix XenDesktop solution), as well as the installed base of more than 70 million end users currently utilizing Presentation Server, we view Citrix Systems as best-positioned to dominate the emerging desktop virtualization market—driving significant potential upside to our long-term estimates. Specifically, we forecast Citrix's XenDesktop revenue to grow to approximately $150 million by 2011, equaling 5.6% of our $2.68 billion revenue estimate for the company as a whole and only 10.0% of the desktop virtualization market. However, if Citrix could capture one-third of the $1.5 billion desktop virtualization market, this incremental contribution would drive revenue upside more than $350 million to our current estimate. Applying our forecasted average corporate operating margin of 25.0% in 2011 for the company to this incremental revenue would produce an incremental $0.34 in earnings per share. We currently forecast 2008 pro forma earnings for Citrix of $1.67 per share, while our 2011 EPS estimate equals $2.99.

  Furthermore, while many investors remain uncertain regarding the potential adoption of XenSource's server virtualization solutions, our combined forecast for both XenDesktop and XenServer revenue (including both license and maintenance revenue) equals $471.7 million in 2011. Therefore, if Citrix could capture one-third of the $1.5 billion desktop virtualization market, this revenue contribution would exceed our combined desktop and server virtualization revenue forecast by $28.3 million. As a result, we believe that investors could include no revenue contribution in their Citrix models from XenSource's server virtualization solutions that compete against VMware's core VI3 platform but still not be concerned about their long-term revenue growth forecasts. In fact, any adoption of XenServer virtualization solutions could be viewed as a call option on overall desktop and server virtualization revenue over the next five years.

  Citrix Systems' installed base of more than 160,000 customers utilize Presentation Server provide end users with desktop access to run applications running on a central terminal server—a solution that we believe could address upwards of 80% of the total desktop end user community. Conversely, desktop virtualization solutions offer "power users" and/or specific "knowledge workers" more performance, data isolation, desktop personalization, and control than can be provided by a traditional server-based

We forecast Citrix's XenDesktop revenue to grow to approximately $150 million by 2011, equaling 5.6% of our $2.68 billion revenue estimate for the company as a whole and only 10.0% of the desktop virtualization market. However, if Citrix could capture one-third of the $1.5 billion desktop virtualization market, this incremental contribution would drive revenue upside more than $350 million to our current estimate. Applying our forecasted average corporate operating margin of 25.0% in 2011 for the company to this incremental revenue would produce an incremental $0.34 in earnings per share.

computing solution, such as Presentation Server.[7] Citrix Systems currently maintains presentation, disk, and application virtualization technologies with Presentation Server, Provisioning Server, and Streaming Server, respectively, as well as user mapping and management tools in Desktop Server. In addition, the company's acquisition of XenSource provides hypervisor and virtual infrastructure management tools to complete Citrix's desktop virtualization offering in the form of the soon-to-be-released XenDesktop solution. XenDesktop closely parallels our vision of a Virtual Desktop Utility, and we believe that the company will offer multiple versions of XenDesktop (i.e., Advanced, Enterprise, and Platinum)—incorporating different combinations of the company's various virtualization technologies and management tools in its product portfolio.

Ultimately, we believe that through combining Presentation Server's unmatched application publishing capabilities and ICA protocol with the soon-to-be-released XenDesktop solution, as well as Provisioning Server and Streaming Server, Citrix Systems is uniquely positioned to satisfy nearly 100% of all desktop user requirements and deployment scenarios with specific solution sets for each scenario's unique requirements.

- *VMware*. VMware, being a leader in the server virtualization space for x86 based systems with proven server-based virtualization technology, is poised to benefit in the desktop virtualization race. VMware has a strikingly different approach to virtualization technology than most of its competitors. While Microsoft, Red Hat, and Novell have built virtualization into the operating system, VMware separates the virtualization from the operating system. Although virtualization built-into the operating system has performance benefits over VMware's approach (around 10~15% improvement), VMware believes that customers can avoid "vendor lock-in" by OS vendors' operating systems.

  Besides server virtualization, VMware currently provides multiple virtual desktop products in the market. With VMware's desktop virtualization technology, customers can run multiple operating systems simultaneously (i.e., Windows and Linux running side-by-side) on a single PC. This solution also allows the creation of multiple virtual desktops on a single server, thereby enabling the use of remote desktop on a thin-client. The VMware Fusion product allows Mac OS X customers to run Windows XP and Vista on Intel-based Macs leveraging the power of Intel Core 2 Duo and Xeon Quad-Core processors available on the latest Mac computers. VMware Virtual Desktop Infrastructure (VDI) separates the centralized desktop from the underlying hardware on which it runs—allowing IT organizations to run multiple, unique, isolated virtual desktops on one physical server. VMware ACE further enhances this capability, allowing the ability to create a virtual desktop image that can reside on a desktop or local storage device (e.g., USB stick or an iPod) and, thereby, eliminating the need of a physical server connection while ensuring security. ACE technology now enables the use of multi-media and 3D graphics on a virtual desktop.

  Ultimately, with proven virtualization technology, we believe VMware can now expand its success in the server virtualization market into the desktop virtualization space.

In addition to the software industry, we believe that IT hardware vendors will not suffer a significant negative effect on their businesses but rather experience a shift in spending from desktops to thin-clients and higher-end servers, where we believe that Hewlett-Packard has developed the strongest roadmap.

- *Hewlett-Packard*. In our opinion, HP stands to gain the most out of the PC and server OEMs in a virtualized desktop environment. As the world's largest vendor of both PCs and servers, HP will experience a meaningful rise in profitability as the mix shifts from PCs to servers, if the company can maintain or gain share during this transition. For example, HP receives 35% of its revenue from PCs, which only have 5-6% operating margins. Meanwhile, revenue from HP's server and storage business is 18% of total,

but carries an operating margin of 10% (a number that has an upward bias to it while the PC profits are closer to peak). Ironically, HP's least profitable PC for the past decade has been its corporate desktop, and as a result, any potential mix shift away from this product is largely positive.

HP has been in the process of building out the hardware industry's most complete virtual desktop solution for several years. In July of this year, HP spent a combined $1.84 billion to purchase both Opsware and Neoware. We believe that Opsware's management software is critical in virtualized server environments, while Neoware augments HP's existing strength in thin client Windows environments by adding capabilities in Linux. Meanwhile, HP's C-Class blades are an optimal solution for virtualized desktop environments on the server side. Notably, HP's presence as the largest vendor of both solutions should help the company set the pace of adoption for the industry and affect the transition on its own terms

State Of The Desktop Union

The Fat PC And Constrained IT Budgets

The commoditization of the PC in the 1980s and 1990s was driven by the emergence of "desktop clones," which ensured declining prices and rising PC adoption. These PCs took over corporate desktops, but to replicate mainframe-like functionality, PCs needed to communicate with other computers, and hence, a client/server strategy evolved in which Windows-based PC clients could access shared resources located on servers running Windows NT or UNIX. With the emergence of the Internet in the mid-1990s, the open-standards Web browser became a new front-end client that was served data and applications by back-end Web servers. The widespread adoption of this client/server network strategy produced many tangible benefits for most organizations but was accompanied by more complexity—expanding maintenance requirements and increasing costs.[9]

As desktops became more and more powerful and networks grew more pervasive, the processing power available on the desktop far exceeded what the typical user needed, and the costs associated with maintaining the Fat PC far outweighed the benefits provided. Expanding bandwidth and multi-megabit connectivity allowed any data or application on the network to be easily accessed. As such, the idea of network computing began to resonate, and an important phenomenon coincident with the empowerment of the desktop user was the budding dependence on Windows-based applications and file formats. Reverting back to centrally-managed, mainframe-like computing would not be feasible if the GUI-based Windows applications were not available to end users.[10]

The advent of thin-client computing in the late 1990s addressed some of the problems with managing distribution systems by enabling a server-based strategy, in which employees would use thin terminals to access centrally-managed data and applications—providing many of the benefits of traditional centralized computing (i.e., powerful servers and simple terminals) with the ability to run modern Windows applications. A thin-client is a display-only device, which displays applications that run on dedicated servers rather than on the desktop computer. Thus, processing is done on large, shared servers that are located in a consolidated and secure data center as opposed to the one-to-one relationship between a user and their desktop PC.[11]

Each progression in computing, from mainframe to PC to client/server, built on its predecessor's technologies, spurring productivity improvements, but also increasing costs and complexity. After the .com bubble burst, organizations became more focused on business growth and minimizing costs—rather than chasing the latest technologies. As such, management shifted their view of IT as a cost burden rather than value creator. The overhead needed to maintain these bloated technologies, drastically limited IT in its ability to support business growth. For example, industry research firms estimate that 75-80% of a typical IT budget is currently being spent strictly on maintaining the complex mix of systems that organizations have developed over time.[12]

Need For Flexible, Cost Effective Desktop Delivery

As little as ten years ago, the concept of desktop management primarily referred to the manual installation of the necessary applications and patches on users' computers. The current IT environment is much more complex—with numerous methods to provide these applications to end users. While many techniques have been implemented to reduce management costs and enable quicker software deployment, IT departments continue to struggle with the cost and complexity of PC management. Specifically, the current desktop computing infrastructure suffers from the following challenges:

- *High TCO*. Almost half a billion PCs exist across IT environments today, and the cost and complexity of managing PCs is growing rapidly for IT organizations. Specifically,

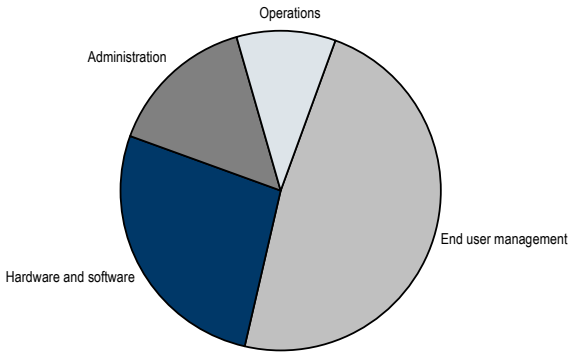
the total cost of ownership (TCO) of a typically managed Windows desktop reaches more than $5,000 per year.[13] (See Exhibit 5.) In fact, the high cost of PC management and support offsets the relatively low cost of PC hardware. Specifically, desktop hardware and software acquisition costs typically account for only 20-30% of the total cost to the customer over the life of the device, while the remaining 70-80% consists of IT maintenance costs, such as moves/add/changes (MACs) of employees, repairs and fixes, and upgrades.[4] (See Exhibit 6.) Ongoing PC management including deployment of applications, software updates, and security patches can be labor intensive because of the need to test and validate deployment for a wide variety of PC configurations.[14]

Exhibit 5: Total Cost Of Ownership Per User Per Year By Corporate Computing Device

	TCO Per User Per Year
Desktop PC	$5,444
Notebook PC	$7,953
PDA	$1,946

Source: Gartner, Credit Suisse.

Exhibit 6: Breakdown Of Total Cost Of Ownership Of The Corporate Desktop

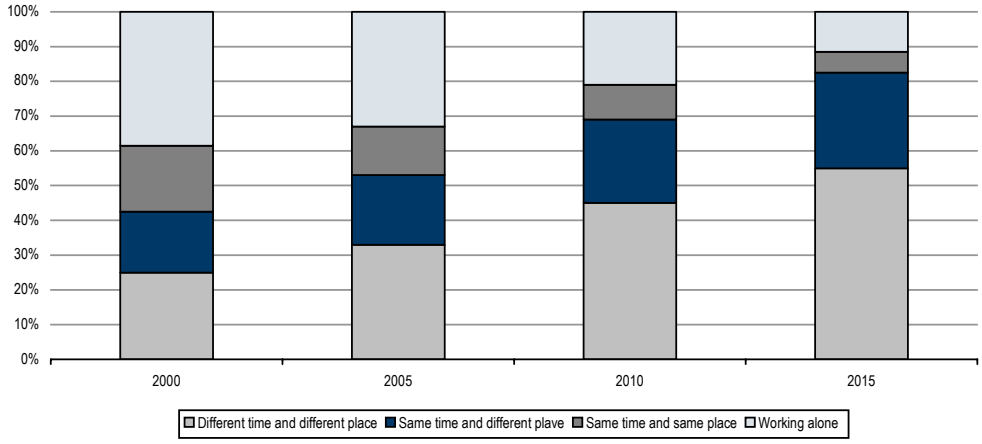


Source: Gartner.

- *Low PC Utilization*. Within large enterprises, server utilization levels range from 15-30%—a level of inefficiency that has driven many organizations to purchase and deploy software solutions that enable server virtualization and consolidation. In comparison, average resource utilization rates for PCs have been estimated at less than 5%.[5]
- *Duplicate Infrastructure For Remote Access and Branch Office*. The distributed nature of PCs creates difficulties in pooling resources to improve utilization and reduce costs. As a result, remote offices require duplicate desktop infrastructure, and additional remote desktop solutions may be required for mobile workers.[14]
- *Security / Data Loss*. Ensuring that data on PCs is successfully backed up and can be restored when PCs fail or files are lost is a significant challenge. Even when data is successfully backed up, the risk of PC theft threatens the security of important data.[14]
- *Application Corruption By Users*. Desktop and application deployment is time consuming and error prone. As such, the probability of a clean install of a new application is largely dependent on the skill of the operator, the window of time available to complete the installation, as well as the fatigue or alertness of the operator.[14] The end user can also delete necessary files from the computer, corrupting the application.

- *Increased Mobility Of Workforce*. Employees are increasingly working from different locations and at different times than in the past—meaning that users require applications and data to be accessible anywhere. (See Exhibit 7.)

Exhibit 7: Evolution Of Work Styles To Rising Mobility



Source: Gartner.

- *Lack of Centralized Management.* Presently, 55% of end users are located in branch offices, and 58% of branch offices and 10% of regional office "hubs" do not maintain a full time IT professional.[15] Centralizing PC management is extremely difficult in the face of broadly distributed PC hardware and users who increasingly require access to their desktop environment from anywhere at anytime. Furthermore, PC desktops are notoriously difficult to standardize because of the variety of PC hardware and users' need to modify desktop environments.[14]
- *Lack Of Flexibility In Disaster Recovery*. For effective disaster recovery, data stored on PCs must be effectively backed up and easily restorable when PCs fail. If a user's PC crashes or a business-critical application is corrupted, the user would have to wait until IT could fix the problem or build a new PC.[14,16]

Will Vista Drive Enterprises To A "Thin" PC Model?

Despite the company's former reluctance to support thin-client computing, Microsoft announced in April 2007 that it will enable new ways to deploy Windows Vista, including new options to license desktop virtualization and diskless PCs. Specifically, Microsoft announced a change in licensing for customers using Windows Vista Enterprise with Software Assurance—adding two new ways to license and deploy the operating system: 1) the license right to use Windows Vista on diskless PCs, which essentially allows companies to stream Vista from servers, and 2) the availability of a subscription license called Windows Vista Enterprise Centralized Desktops (VECD), which allows customers to use Windows in virtual machines centralized on server hardware. Essentially, the diskless PC and centralized virtual machine licensing changes enable enterprises to deploy OS streaming or virtual desktop technologies, respectively, while still maintaining compliance with Microsoft license agreements.

In addition to the licensing changes associated with Windows Vista, we believe that the hefty system requirements for Vista (i.e., recommended mid-range or better processor and at least 1 GB of memory for advanced users) could potentially drive some organizations to consider thin-client implementations rather than deploying the necessary hardware upgrades on end user PCs. For example, Vista's minimum CPU requirements are approximately 240 percent larger than that of Windows XP. Additionally, the minimum memory requirements increased from 64 MB for Windows XP to 512 MB for Windows

Vista. For many organizations, enabling the current user installed base of PCs could entail expensive and time consuming hardware upgrades or actual replacement of PCs with Vista-capable systems.[17]

Server-based computing models, for example, lower end user hardware requirements, and we believe that organizations may look to these strategies as a way to utilize existing hardware but still be able to run the latest software. Organizations would not only avoid PC upgrade costs but also realize the other benefits of lower management costs at the client machine when moving to server-based computing.[18]

Furthermore, when utilizing a virtual desktop infrastructure, companies migrating to Vista need not upgrade their physical PCs but instead can tune the virtual machines to be "Vista ready" by allocating more CPU and memory resources on backend servers via the hypervisor layer and associated management tools. Application virtualization strategies could also facilitate Vista migrations by reducing problems with application conflicts. Streamed, virtualized applications can ease the deployment of software applications by encapsulating them inside "virtual sandboxes," thus avoiding potential crashes resulting from incompatible applications, which accounts for approximately one third of traditional Windows application installations.[18,19] With application virtualization, each application runs in its own virtual environment, eliminating many of the application conflicts seen with traditional SBC and other application delivery methods.

By combining by desktop and application virtualization technologies, companies can not only minimize the effects of Vista's increased CPU and memory demands on end user PCs but also lessen the impact of application conflicts. Similar results can also be achieved when IT departments utilize presentation virtualization (i.e., server-based computing) in combination with application virtualization and isolation.

Desktop Management Models

While desktop virtualization represents the most recent evolution of desktop delivery and management, we expect a "mixed environment" to exist—even within organizations utilizing virtual desktop technologies. Advantages and disadvantages exist to local and central execution, shared and private environment, and local and central management models. Selecting one option over another (or employing a combination) is based on a combination of both user and IT needs/requirements. As such, we describe the advantages and disadvantages of eight architectures that can be utilized to deliver Windows desktops and applications to end users in the following sections.

Shared Hardware With Centralized Management

Presentation Virtualization (Published Desktop In Server-based Computing)

The paradigm of server-based computing (SBC) is based on the goal of cost reduction through the centralization of IT resources and entails installing applications on a central terminal server and then providing Remote Desktop Protocol (RDP) or Independent Computing Architecture (ICA) access from client terminals. Server-based computing technologies, such as Citrix Systems' Presentation Server, provide on-demand access to applications more efficiently and reduce associated technology costs by centrally managing and deploying computing applications in server farms in centralized data centers. From a macro perspective, larger server farms supporting more applications at higher densities provide even greater cost savings and in turn drive further adoption of server-based computing.

The advent of thin-clients and blade computing in the late 1990s enabled a server-based strategy in which employees would use thin terminals to access centrally-managed data and applications, providing all the benefits of traditional mainframe-based centralized computing (i.e., powerful servers and simple terminals) with the ability to run modern Windows applications. A thin-client is a display-only device, which displays applications that run on dedicated servers rather than on the desktop computer. Thus, processing is done on large, shared servers that are located in a consolidated and secure data center as opposed to the one-to-one relationship between a user and their desktop PC.[11]

The advent of thin-clients and blade computing in the late 1990s enabled a server-based strategy in which employees would use thin terminals to access centrally-managed data and applications, providing all the benefits of traditional mainframe-based centralized computing (i.e., powerful servers and simple terminals) with the ability to run modern Windows applications.

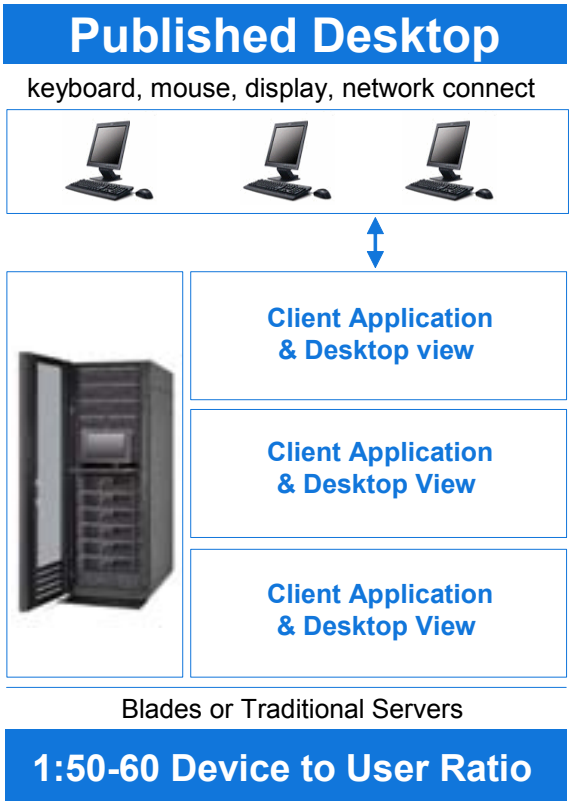
The movement to thin-client terminals and server-based computing dramatically lowers the total cost of ownership of the end user's device, as the IT associated with managing that end user terminal is reduced significantly through the centralization of applications. Specifically, the total cost of ownership (TCO) of a Windows-based computing terminal equals slightly more than $2,500 as compared with the typically managed Windows desktop's TCO of more than $5,000—representing significant cost savings.[13] We believe that the migration to thin-client computing represents a compelling cost savings for enterprises looking to create funds available for redeployment from maintenance activities to potentially new business-focused initiatives.

Much of the cost savings equation is driven by the fact that server-based computing delivers user applications in a fundamentally different way than the traditional desktop PC in a client/server approach, and thus, a migration to SBC requires a fundamental shift in the service delivery structure. SBC is not, however, an all or nothing approach and with many organizations accustomed to applications built for a client/server environment, a hybrid approach that encompasses SBC and client/server components will most likely be a pathway to full SBC migration.[11]

Exhibit 8: Published Desktop "Stack"

Source: Citrix Systems

Exhibit 9: Published Desktop Delivery Architecture



Source: Citrix Systems, Credit Suisse

Advantages

- *IT Cost Reduction*. SBC lowers the total cost of ownership of IT with reduced hardware depreciation costs; reduced costs associated with moves and changes; and reduced remote data center and business continuity charges. SBC provides more effective cost management with increased centralization and utilization of large data centers. Overhead savings could also be realized with reduced desktop support headcount and reduced packaging and distribution charges.[11]
- *Centralized Application Management*. SBC provides a server centric architecture that enables the deployment and management of applications on a centralized basis, avoiding the need to attend desktops directly. This provides multiple benefits, including staff mobility due to simplified remote access, rapid deployment of new applications, and greater flexibility and reliability.[11]
- *Increased Flexibility And Mobility*. SBC provides an architecture capable of extending to remote sites without the need for extensive capital expenditures and it provides the capability to efficiently provide external entities or newly merged entities access to applications without the need for application or server installation. The centrally-managed system also enables simplified remote access and roaming personal desktops for mobile employees.[11]
- *Increased Scalability*. Capacity planning and control is greatly enhanced when deploying applications from centralized servers. Larger processor machines could be utilized to run applications from the server room where it would be infeasible to run at a user's desk. Efficient use of existing capacity enables scale to grow without additional investments at each incremental point of scaling.[11]

- *Increased Security*. SBC can provide security benefits by minimizing the local exposure of corporate systems, networks and data and the transfer of malware through remote displays or thin-clients is rare. When system updates are critical to avoid security breaches, SBC reduces the concerns of patch management since change control for software and data is centralized and updates necessary for clients are minimal.[11]

Disadvantages

- *Back-end Connectivity Required*. In a server-based computing architecture, client devices must be connected to the network in order to use the applications that reside on the terminal server. Loss of network connectivity—either anticipated (e.g., laptop connectivity on a flight) or inadvertent (e.g., network outage)—would prevent access to essential applications.[16] Additionally, applications—particularly graphic-intensive ones—can experience performance problems or become unavailable because of network problems, heavy printing demands, and large file transfers over low-bandwidth connections.[20]

- *Multi-user Environments Not For All Applications*. One of the main drawbacks to the SBC paradigm is that not all existing applications will run in a multi-user environment and thus, some applications would need to be re-written, retired, or continued within a Fat PC architecture.[11] With Citrix MetaFrame 1.8 and XP, some applications would conflict with other applications and some applications would require dedicated IP addresses to properly function. Citrix Presentation Server 4.0 addresses some of these conflicts with new features including application isolation and virtual IP address support. Application Isolation provides a virtualized environment for access to files, registries, and named objects, which enables applications that are incompatible with each other to run simultaneously. Virtual IP support allows administrators to set aside a group of IP addresses for use by applications that require separate IP addresses per session—which would be useful for an application that identifies a user session by an IP address.[21,22] Application isolation does not, however, address all issues that create application conflicts in an SBC environment. For example, some applications that install and depend on a device/kernel driver or certain Windows services may still not function properly.[21]

- *Data Center Must Be Built Out*. Although adequate cost savings are usually realized in a three to five year time frame due to the lower data center and maintenance costs, initial capital investments to build out the SBC infrastructure can be rather high. Investments for data center servers, Citrix and Terminal Services licenses, thin-clients, as well as the IT personnel to support the SBC architecture, may represent a significant hurdle for some companies depending on their size and IT budgets.[16]

- *Applications Must Be Packaged*. In an SBC environment, all applications—commercial or custom-built—must be packaged so that it can be delivered across RDP or ICA from the terminal server. Commercial tools, such as Citrix's Installation manager or Altiris RDP, can be used to prepare applications for SBC deployment. However, this process adds to the deployment time of any new application that needs to be accessed.

- *Limited Personalization*. Published desktops provide a standardized environment for user. Difficulties arise when users need to install and modify applications if needed, given that changing applications and settings can impact other users.

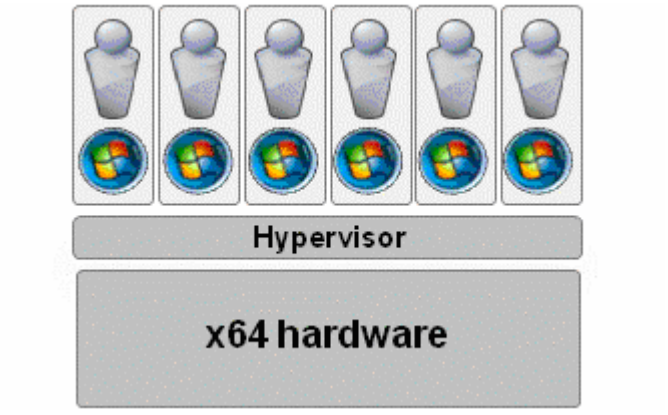
Virtual Desktop

The virtual desktop architecture entails building a large Microsoft Virtual Server, VMware, or Xen server and dividing it into multiple virtual machines with each running Windows and then providing access to the virtual machines via Windows' built-in remote desktop protocol (RDP) or an imbedded ICA stack via the Citrix's soon-to-be-released "PortICA Project."[16]

Building a server-based desktop solution with a virtual desktop infrastructure makes it possible to address PC desktop challenges while optimizing usability, manageability, TCO, and flexibility. With a virtual desktop infrastructure, complete desktop environments—operating system, applications, and configurations—reside in virtual machines. End users use remote display software to access their desktops from a PC or thin-client.[6]

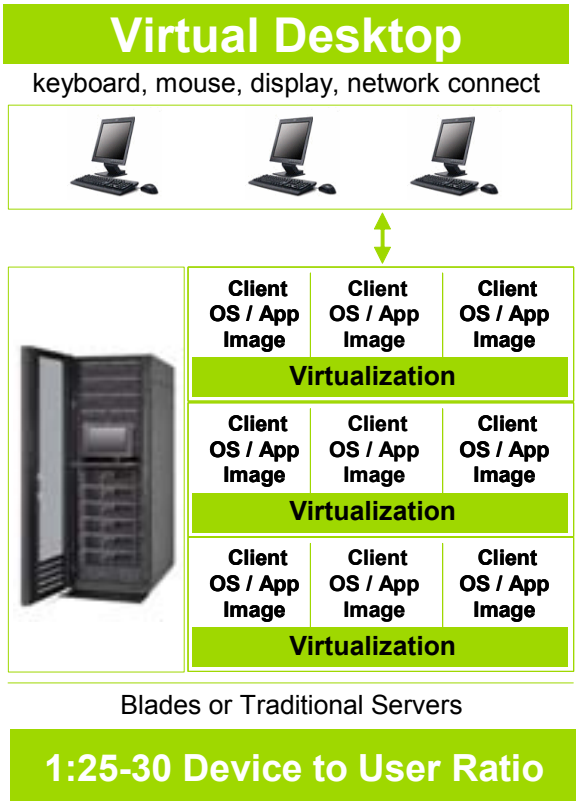
The virtual desktop option is similar to the bladed PC option, except this desktop delivery scenario has each end user going to a Windows session in a virtual machine instead of his/her own native blade. Virtual machine sessions can be suspended and unloaded from memory and resumed later on, much like hibernating a desktop. For example, after a 30 minute idle period when the user's session is disconnected, the session would remain active on the server for four hours before the virtual machine is suspended and its memory contents dumped to disk. At this point the virtual machine is consuming no server resources and can stay suspended, but when the user comes back, the session is retrieved from disk and restored to any available server—allowing the user to pick up wherever he/she left off.[16]

Exhibit 10: Virtual Desktop "Stack"



Source: Citrix Systems.

Exhibit 11: Virtual Desktop Delivery Architecture



Source: Citrix Systems, Credit Suisse.

Advantages

- *Maintain Desktop User Experience*. The virtual desktop solution centralizes desktop computing and storage resources into data centers and allocates a virtual machine to each end user. The processing, storage, and networking have been moved to the data center with access to applications, data, and their own personal computing environment within the user's virtual machine environment. In this strategy, each user has a dedicated computing resource running a single instance of the operating system, providing an enhanced, personalized desktop that can be remotely accessed through enterprise networks or the Internet.[23]

- *High Level Of Security.* Virtual desktop infrastructure solutions let remote users access applications that reside in the corporate data center and adhere to company-approved security policies; intellectual property is not sent overseas where it is difficult to secure; and data resides on the corporate network where regulatory compliance can also be followed strictly. When a third-party contract is terminated or an employee leaves and network access is shut off, data still resides in the host country.[6]

- *Improved Price/Performance Versus Blade PCs*. The virtual desktop architecture provides much better price/performance than the bladed PC architecture. While still providing the end user with a desktop experience, the virtual desktop solution does not maintain a one-to-one relationship between servers and users as with the bladed PC architecture, which provides much more efficient utilization of computing resources.[16]

- *IT Cost Reduction*. A virtual desktop lowers the total cost of ownership of IT with reduced hardware depreciation costs, reduced costs associated with moves and changes; and reduced remote data center and business continuity charges. A virtual desktop infrastructure provides more effective cost management with increased centralization and utilization of large data centers. Overhead savings could also be realized with reduced desktop support headcount and reduced packaging and distribution charges.[24] Specifically, rapidly falling IT hardware prices have allowed corporations worldwide to significantly lower their internal IT capital expenditures. However, desktop computing acquisition costs typically account for only 20-30% of the total cost to the customer over the life of that hardware, while the remaining 70-80% consists of IT maintenance costs, such as moves/add/changes (MACs) of employees, repairs and fixes, and upgrades.[25] Furthermore, administering 250 servers costs significantly less to manage in both time and money than 5,000 desktop instances across an organization.

- *Increased Flexibility And Mobility*. A virtual desktop architecture is capable of extending to remote sites without the need for extensive capital expenditures and provides the capability to efficiently provide external entities or newly merged entities access to applications without the need for application or server installation. The centrally-managed virtual desktop system also enables simplified remote access and roaming for intra-office personal desktops for mobile employees.[24] The ability to connect to a single desktop image whether sitting at one's cubicle, logging in remotely, or traveling to a branch office through Citrix System's Smooth Roaming technology is a component of virtual desktop infrastructures that enables hot desking and worker mobility.

- *Improved Disaster Recovery*. Complete desktop environments are encapsulated inside virtual machines and maintained in the corporate data center where, in the event of a disaster, they can be instantly recovered and redeployed. Moreover, if one user's desktop crashes, it will not affect another user's desktop or application because it is running in a separate virtual machine.[26]

- *Increased Scalability*. Capacity planning and control is greatly enhanced when deploying applications from centralized virtual machines. Larger processor machines could be utilized to run numerous desktop images from the server room as opposed to deploying individual machines at each user's cubicle. Furthermore, partitioning a large server into VM images represents a more cost-efficient solution to PC blades. Efficient use of existing capacity enables scale to grow without additional investments at each incremental point of scaling.[24]

- *Simplified Operational Management*. Organizations with branch offices, remote workers, or offsite facilities can manage and standardize their desktop environments and applications in the corporate data center, where backups, upgrades, and complete maintenance can be performed from one central location. Virtual desktop infrastructures simplify software image updates—both operating system and application—because the entire software image resides on one file on the server.

- *Desktop Customization/Personalization*. A virtual desktop infrastructure can provide a unique environment for each and every user, and each of these environments can be completely customized with different applications and settings without impacting other users. Furthermore, users can be granted more control of their own "virtual" desktop to allow them to install and modify applications if needed.[27]

- *Increased Security And Compliance*. Transfer of malware through remote displays or thin-clients is rare. Furthermore, from a compliance standpoint, a virtual desktop infrastructure is ideal for offsite facilities used for development, call centers, back order processing, or other transaction-based tasks where confidential information and intellectual property can be securely stored and maintained in the corporate data center. Virtual PCs enable organizations to move sensitive data normally stored on a PC into the corporate data center to maintain data integrity and meet regulatory compliance requirements (e.g., HIPAA, Sarbanes-Oxley, and Gramm-Leach-Bliley).[26]

Disadvantages

- *Data Center Must Be Built Out*. Initial capital investments to build out the virtual desktop infrastructure can also be rather high. Investments for data center servers, VMware or Microsoft virtualization solutions, as well as the IT administrators to manage the virtual desktop architecture, may represent a significant hurdle for some companies depending on their size and IT budgets.[16]

- *Greater User To Server Ratio With Published Desktops*. A typical server is capable of hosting approximately 25-30 virtual desktops, whereas that same server could host 50-60 published desktops (e.g., via Presentation Server). Therefore, while certain users within an organization may require the personalization and performance of a virtual desktop (e.g., knowledge workers, programmers, traders, etc.), published desktops offer better capital cost efficiency, making them more financially applicable to employees in administrative roles.

- *Need For Robust Virtual PC Management Tools*. As virtual machine technology moves out of development labs and into production server environments in large numbers, some administrators are finding that the growth of virtual servers is getting ahead of the tools available to effectively manage them. Existing server-monitoring tools are increasingly aware of virtual servers, but most lack the sophistication to interpret feedback in a virtual machine context. For many organizations, identifying the root cause of virtual server problems and rectifying them remains largely a manual process. As the number of virtual machines in the data center increases, solving those problems in an automated way becomes more urgent.[28]

Dedicated Hardware With Centralized Management

Blade PC

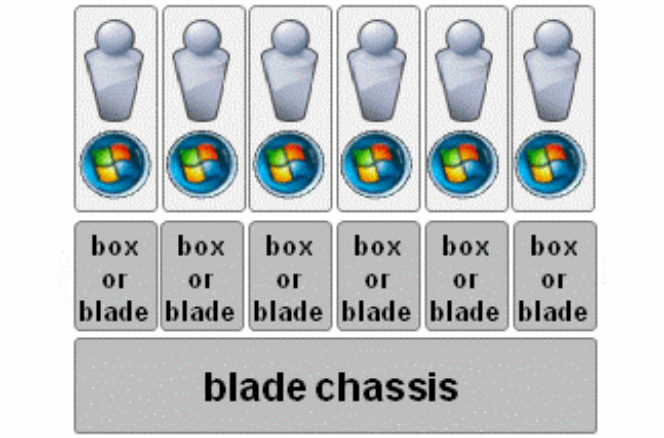
A blade PC is the name associated to an approach where bladed servers are used as end user workstations. In a bladed PC environment, Windows is installed on a server blade and then remote access is provided through Windows' built-in RDP remote desktop functionality. HP, Dell, and IBM produce server blades that are basically regular servers except that the form factor is a removable device that fits into a chassis.[16]

A single chassis can house a number of servers—typically fourteen servers or more—and the chassis provides common network I/O and, optionally, common storage I/O services for all blades. Multiple blade servers also share common components, such as CD-ROMs, floppy drives, keyboard, monitor, etc. While much denser than standard rack-mounted servers, bladed servers also consume less power and are easier to manage.[16]

Blade servers can be purchased in uni-processor, dual-processor, and four-way configurations. Furthermore, individual blades housed in a chassis can be added, removed,

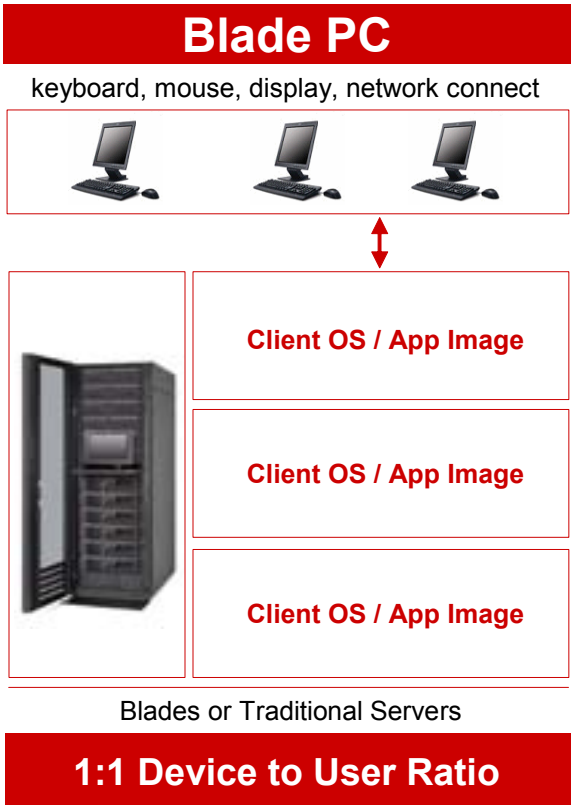
or replaced without disturbing other blades in the same chassis. The serviceability advantages, coupled with the high density of blades, make blade servers an appealing infrastructure choice for thin-client implementations.[13]

Exhibit 12: Blade PC "Stack"



Source: Citrix Systems

Exhibit 13: Blade PC Delivery Architecture



Source: Citrix Systems, Credit Suisse

Advantages

- *Maintain Desktop User Experience.* The bladed PC solution centralizes desktop computing and storage resources into data centers but also provides end users with the convenience and familiarity of a traditional desktop by dynamically allocating a one-to-one connection between each user's thin-client and an individual blade PC. While the processing, storage, and networking have been moved to the data center, the desktop experience for the user is unchanged—with access to applications, data, and their own personal computing environment. In this architecture, each user has a dedicated computing resource running a single instance of the operating system, providing an enhanced, personalized desktop that can be remotely accessed through enterprise networks or the Internet.[23]
- *High Level Of Security*. The bladed PC architecture provides a high level of security because a company's valuable resources, such as intellectual property and confidential information, are stored and backed up in the datacenter. Additionally, because each user accesses a single blade exclusively, each user's actions will only affect their respective blade.[23]
- *Smaller Footprint And Lower Power Consumption Than Traditional PCs.* The blade PC strategy requires less space and consumes less power than the traditional Fat PC environment. Thin-clients, as opposed to traditional PCs, consume less power and space on the user's desktop. Bladed servers are much higher density than standard

rack-mounted servers (e.g., 20 blades can fit in 3U of rack space), and all the blades in a chassis share common components (e.g., CD-ROMs, floppy drives, keyboard, KVM, etc.), which translates to a smaller footprint and lower power consumption.[23]

Disadvantages

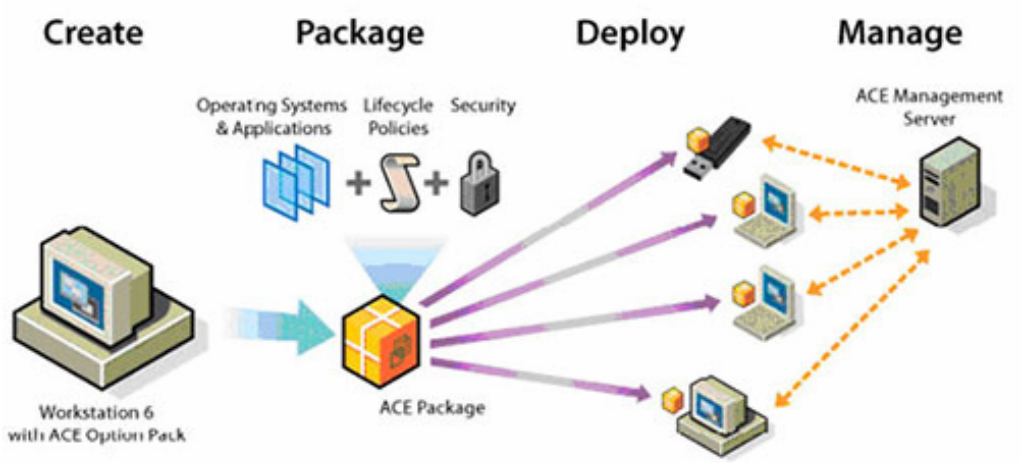
- *Expensive*. While the centralization of the computing resources into data centers should provide some management benefits over maintaining PCs at user locations, the one-to-one relationship between blade servers and users can result in significant cost for acquiring the necessary blades. Additionally, data centers would have to be built out with the shared storage and networking components (e.g., SAN, NAS, etc.).[16]
- *Network Connectivity Required*. In a bladed PC architecture, thin-client devices must be connected to the network in order to access the blades in the data center. Loss of network connectivity would, in essence, be equivalent to an inoperative desktop PC.[16]
- *Management Tools Needed.* Management tools are needed to manage the software within each bladed PC. Managing the blade servers and integrating them with other system resources is becoming important to companies as blades become more widely adopted. Server makers are opening their management toolkits to third-party developers, increasing support for each other's hardware, and integrating blade systems with other computing resources more tightly. The benefits of blades will increasingly depend upon management efficiency and flexibility as hardware becomes more commoditized.[29]

Client Hosted Desktop

A virtual machine on the desktop is unique in that an entire desktop environment is created and managed centrally but is then run on top of an already existing desktop environment hosted by a PC or remote device through use of a hypervisor layer. This model is quite different from the server-hosted and desktop streaming models, but it does offer certain benefits that the others cannot. Specifically, since the desktop environment is being completely hosted on top of an operating system of a remote device, it does not require constant connection with a server. As such, a client hosted desktop represents an ideal way to offer centrally-managed desktop environments to mobile and non-corporate remote users. The virtual machine sitting on top of an operating system is seeing adoption—particularly for extending the corporate environment for home users, outsourced workers, and disaster recovery and supply chain partners.[30]

For example, administrators can now bundle and deploy VMware ACE packages directly on a portable USB media device (e.g., flash memory stick, portable hard drive, or even an Apple iPod), and end users can operate their ACE client machines directly from the USB device for mobility and flexibility. Through client hosted virtual machines, IT administrators can deploy managed virtual laptops to remote workers and third-party, unmanaged PCs for a lower cost and easier to manage solution than an additional fully-configured laptop, and the technology also enables the creation of “sandbox environments” that provide end users with an isolated, secure virtual machine for accessing corporate resources, while providing another more open, configurable environment that requires less control.[31]

Exhibit 14: **VMware ACE**



Source: Vmware.

A hosted desktop also allows users to evaluate virtual appliances with ease. For example, VMware's VMware Player enables the simple evaluation of one of the many virtual appliances available through the VMware Virtual Appliance Marketplace. A virtual appliance is a pre-built, pre-configured, and ready-to-use enterprise software application on a virtual machine. With VMware Player, users can quickly and easily experience the benefits of preconfigured products without any installation or configuration hassles. With VMware Player, users can use any virtual machine created by VMware Workstation, VMware Server or VMware ESX Server, as well as Microsoft virtual machines and Symantec LiveState Recovery disks, and use Windows, Linux, NetWare, or Solaris x86 operating systems side-by-side, without rebooting or partitioning the local hard drive.[26]

Advantages

- *Increased Flexibility And Mobility*. A hosted desktop infrastructure provides an architecture capable of extending to remote sites without the need for extensive capital expenditures and provides the capability to efficiently provide external entities or newly merged entities access to applications without the need for application or server installation. The centrally-managed virtual desktop system also enables simplified remote access and roaming for intra-office personal desktops for mobile employees.[24]
- *Improved Disaster Recovery*. Complete desktop environments are encapsulated inside virtual machines and maintained in the corporate data center where, in the event of a disaster, they can be instantly recovered and redeployed. Moreover, if one user's desktop crashes, it will not affect another user's desktop or application because it is running a separate virtual machine.[26]
- *Simplified Operational Management for Desktop Image*. Organizations with branch offices, remote workers, or offsite facilities can manage and standardize their desktop environments and applications in the corporate data center, where backups, upgrades, and complete maintenance can be performed from one central location.
- *High Level Of Security*. The client hosted desktop provides a high level of security because a company's valuable resources, such as intellectual property and confidential information, are stored and backed up in the datacenter.[23] While remote users may be lax in protecting their own PC environment, the virtual machine session that sits on top of the hypervisor layer on the local operating system is protected with centrally-managed security policies.

- *Rebooting Resets Machine To A "Good" State*. If a user's image on top of their desktop environment becomes corrupted, a simple reboot can reset the machine to a "good" or "trusted" state without the need for a reboot of the local hard drive. Since desktop hosting delivers the complete PC image to the client from a remote file server, the OS image can be maintained in a controlled and secure location.[16]

- *Centralized Application Management*. The hosted desktop provides a server centric architecture that enables the deployment and management of applications on a centralized basis, avoiding the need to attend desktops directly for application support. This provides multiple benefits, including staff mobility due to simplified remote access, rapid deployment of new applications, and greater flexibility and reliability.[11]

- *Network Connectivity Not Required*. In a hosted desktop architecture, remote client devices need not be connected to the network at all times in order to access the corporate desktop image. Specifically, since the desktop environment is being completely hosted on top of an operating system of a remote device, it does not require constant connection with a server. As such, it is an ideal way to offer centrally-managed desktop environments to mobile and non-corporate remote users.[30]

Disadvantages

- *Data Center Must Be Built Out*. Initial capital investments to build out the virtual machine infrastructure can be rather high. Investments for data center servers, VMware or Microsoft virtualization solutions, as well as the IT administrators to manage the virtual desktop architecture, may represent a significant hurdle for some companies depending on their size and IT budgets.[16] While the VMware Player utility is offered free of charge, other products are necessary to actually create and manage the desktop image (e.g., VMware Workstation, VMware Server, VMware ESX Server).

- *TCO benefits Varies*. While the centralization of the user desktop image into data centers should provide some management benefits over maintaining the desktop image at user locations, the client desktop management at the remote user site could require similar overhead as the traditional PC environment.[16] The relatively low cost of PC hardware could be more than offset by the high cost of management and support of the software and hardware beneath the hypervisor layer.

- *Performance Implications*. Since hosted virtualization runs a virtualized software layer directly on top of the standard operating system, the virtualization layer relies on the OS to interface directly with the underlying hardware. A major problem with hosted virtualization is that it can significantly impact performance due to the system overhead, making it a less desirable virtualization method for enterprise and distributed applications.

- *Similar Power Consumption with Traditional PCs.* The hosted desktop strategy requires similar space and consumes similar power as the traditional Fat PC environment. Although the desktop image is managed centrally in the data center, the traditional PCs at the remote user site do not provide the power consumption benefits that thin-clients offer.

- *Management Tools Needed.* Management tools are needed to manage the virtual machines that are intended to sit on top of the local operating system. For example, if organizations need to create virtual machines as well as leverage developer-centric features, multiple snapshots and clones, or virtual rights management features for end-point security, they will need the appropriate management product.[26] As virtual machine technology moves out of development labs and into production environments in large numbers, some administrators are finding that the growth of virtual machines is getting ahead of the tools available to effectively manage them. Existing server-monitoring tools are increasingly aware of virtual servers, but most are not yet sophisticated enough to interpret feedback in a virtual machine context. For many

organizations, identifying the root cause of virtual server problems and rectifying them remains largely a manual process. As the number of virtual machines in the data center increases, solving those problems in an automated way becomes more urgent.[28]

Automated Software Distribution

As IT environments became larger and more complex, the deployment and management of desktop applications via traditional methods became unfeasible. Legacy applications and hardware, as well as client/server-based applications, had to work with operating systems and applications that required constant updates, which led to an extremely difficult set of systems to manage. The larger the environment, the more hardware and software systems there were to interact and interoperate, and if a particular system was out of sync with the necessary version level, compatibility issues, support costs, and lost productivity would often result.[19]

The challenge of managing a "Fat PC" environment centers on not only the volume of the devices but also the infinite permutations and combinations of software and hardware products that are possible if users are allowed unlimited flexibility to select their own options. Vendors in the desktop management space offer products that help organizations standardize the desktop applications and control changes to the environment.[32]

Automated software distribution tools, such as Microsoft's SMS or Altiris' Client Management Suite, primarily focus on installing and updating applications or operating environments on end users' computers. With these software distribution solutions, an administrator can inventory software and hardware configurations, distribute software, perform remote troubleshooting, store information in a centralized database, and customize and integrate the solutions with internal processes. Administrators can thus create a standardized application package and then push out the package from a central or primary site server to simultaneously install on hundreds of desktops at disparate locations.[16]

Advantages

- *Centralized Application Management*. Centralizing application administration leads to greater IT efficiency and lowers the cost of computing. Before automatic software distribution tools were available, an operator would take hours to physically install an application or an update on each system. With automated software distribution, the operator can push out a software installation across multiple desktops from a central management server. Managing the installation centrally provides a better probability that the correct image is installed and is consistent across all systems. Improvements in the networking paradigm and software distribution tools enable organizations to cut down the lead time for rolling out applications and reduces the need for IT staff in all remote locations, reducing the costs of running, and maintaining the IT environment.[33]

- *Improved Application Inventory Management*. Under an automated software distribution architecture, applications installed on end users' PCs can be easily inventoried, giving the IT staff the ability to install and keep an audit trail. IT administrators, therefore, obtain more management control over what goes out to the enterprise, and they can track what software has been installed on what machine.[34] The mission-critical nature of IT infrastructure requires timely resolution of help desk problems, which require quick identification of the problem in the first place. With the increasing complexity of the network environment, problem resolution becomes much more difficult without the appropriate tools, and software inventory can quickly lead to the appropriate fixes without interrogating a user who may have limited information on the machine.[19]

Disadvantages

- *Application Corruption By Users*. While automated distribution of software and updates increases the probability of a clean install when compared to the error-prone manual process, the application code still resides on the local user desktop. An administrator surrenders much control of the application code after the install is complete, giving users the ability to mismanage and inadvertently corrupt the software installed on their systems. Troubleshooting and fixing a user's software corruption often requires the reinstallation of the affected application, resulting in even more support costs and lost productivity.[16]

- *Lack of Flexibility In Disaster Recovery*. Once again, after automated installations and updates are complete, OS and application software reside on the local desktop, leaving the desktop susceptible to the same disaster recovery issues as with manual installation. A PC crash or application corruption can take down a worker until IT can build a new PC. Ensuring that data on PCs is successfully backed up and can be restored when PCs fail or files are lost is a significant challenge. Even when data is successfully backed up, the risk of PC theft threatens the security of important data.[14,16]

- *Application Conflict Testing Required*. Application conflicts are constant nuisances for IT administrators as an estimated one-third of Windows applications conflict with one another when installed. Applications overwrite common settings in the Windows Registry, install different versions of components, and utilize common resources, destabilizing the functionality of other installed applications. Furthermore, different versions of the same application often cannot run simultaneously on a single computer, as one version may overwrite the settings or contents of the other. Since predicting which applications will conflict remains difficult, IT must spend an inordinate amount of time regression testing them on staging machines and then on production systems, before deployment.[35]

Application Virtualization

Application streaming solutions, such as Softricity's SoftGrid, Altiris' SVS, or Citrix Systems' Streaming Server, enable the dynamic delivery of applications to end users' desktops from centralized servers. While similar to server-based computing, the fundamental difference between application streaming and SBC is that the application is not actually run on the central server. Instead, when a user launches an application from the client in an application streaming environment, the server streams the necessary application files to the user's PC and the application launches. The key point is that not all of the files are sent to the PC—only what is required to run that particular application is streamed (i.e., when launching Excel, the whole 300 Mb Office application will not streamed down). Additionally, each application runs in its own virtual environment, eliminating many of the application conflicts seen with SBC and other application delivery methods. For example, a user will not be able to find the Office registry keys on the local PC.[36]

One difference between Altiris' SVS and Softricity's SoftGrid solutions is that SVS is machine-specific, deploying a virtualized application to a specific client system, while SoftGrid focuses on a user's login credentials, allowing applications to follow the user from machine to machine with all settings and preferences preserved. Another difference is that Softricity uses true streaming, delivering only portions of the application's code base in byte streams, while SVS requires the entire virtualized application package to be delivered before it can be activated.[37]

Advantages

- *Centralized Application Management*. Similar to server-based computing, application streaming also provides a server centric architecture that enables the deployment and

management of applications on a centralized basis, avoiding the need to attend desktops directly. This provides multiple benefits, including staff mobility due to simplified remote access, rapid deployment of new applications, and greater flexibility and reliability.[11]

- *Simplified Operating System Migrations*. Since application streaming delivers applications on demand without installation, the need to pre-install applications in an OS image is eliminated—reducing the size of the image and allowing for quicker deployment and migration times. An image only needs to contain the standard set of corporate utilities (e.g. antivirus, personal firewall, etc.) and applications (e.g., "core" version of Microsoft Office, Adobe Acrobat Reader, etc.). Image management without application streaming would be more difficult and time consuming as a separate OS image must be configured, regression tested, and managed for each unique client configuration, which would contain all the included applications.[35]

- *Accelerated Application Deployment*. Application streaming allows quicker deployment of applications by providing on demand access to applications that are needed from any computer. Since each application executes inside its own virtual space, applications will not conflict with existing applications on a user's desktop and, thus, regression testing will not be needed. Additionally, it is no longer required to install all applications, which reduces the size an complexity of system images as well as the number of images that must be maintained across the environment for different user communities.[35]

- *Improved Security*. By isolating applications from the operating system, the operating system is protected from malicious attacks through the applications. Since an application runs in its own virtual space, the threat of a widespread outbreak is contained. With application virtualization, if malware does infect one application, the chances that it will compromise other applications or the operating system are greatly reduced. For example, if an enterprise deploys the Internet Explorer application in a virtual environment, all unwanted malicious code is contained only in that virtual environment.[35]

- *Virtualization Eliminates Application Conflict*. By eliminating installations and shielding the operating system and applications from changes that are normally created when applications are installed and run, application virtualization prevents the technical problems that hinder deployments. Because each application executes inside its own virtual "sandbox," inter-application conflict is eliminated, and any application can run alongside any other. Even multiple versions of the same application (e.g., Office 2003, Office XP and Office 2000) and multiple database client versions (e.g., SQL, Oracle and Sybase) can run on the same device at the same time.[35]

Disadvantages

- *Data Center Must Be Built Out*. Similar to building out the SBC architecture, initial capital investments to build out the application streaming infrastructure can be rather high. Investments for data center servers, streaming or virtualization solutions, such as SoftGrid, SVS, or Streaming Server, as well as the IT administrators to manage the application streaming architecture, may represent a significant hurdle for some companies depending on their size and IT budgets.[16]

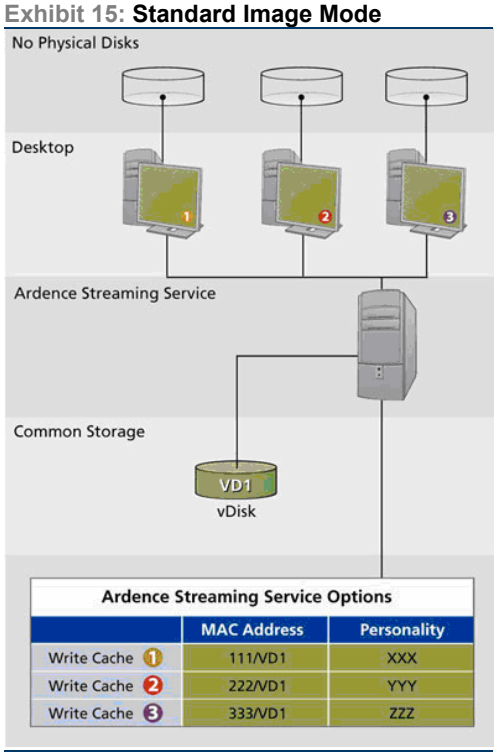
- *Applications Must Be Sequenced And Packaged*. For an application to be available in a streaming environment, the application would first need to be sequenced and then packaged. A sequencer tool prepares an application for streaming by monitoring the installation and running of the particular application to be streamed. For example, to sequence Microsoft Office, one would launch the sequencer and then the Microsoft Office installer and then run the necessary applications from Office. The sequencer records all the information, such as files created, files necessary to run the application,

registry entries, etc., in a couple of packages. The package is then copied to the server that will actually deliver the application to the client machines. If a new application is to be added, the sequencing PC must be reverted to pristine state, and the process will be repeated.[36]

PC Disk Virtualization (Diskless PC)

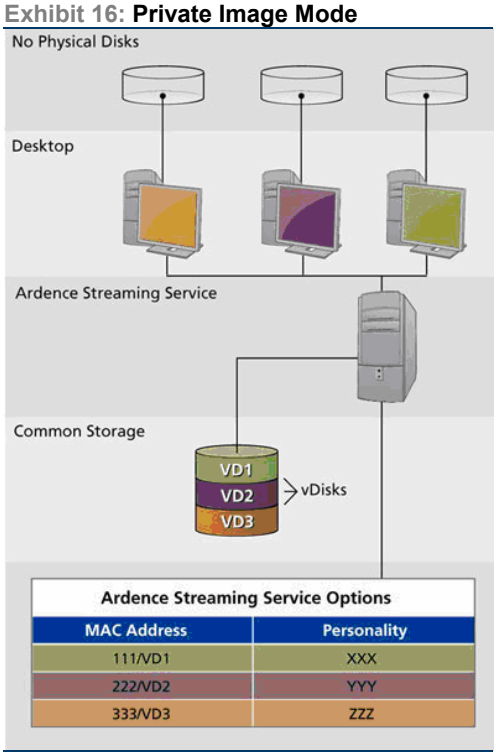
With diskless PCs run via remote boot software, the client operating system is pre-installed into an image file that is stored on a centralized storage system such as a Storage Area Network (SAN) rather than on a local hard drive. Diskless PC solutions enable local "chubby clients" to boot off of a single, centralized disk image—including operating system and applications—that is executed on the end users' devices using local resources. This allows for a dynamic environment in which an OS, applications, and data can all move freely among client machines.[38]

Exhibit 15: Standard Image Mode



Source: Citrix Systems

Exhibit 16: Private Image Mode



Source: Citrix Systems

These solutions launch an entire disk image on the user's client device by providing a network-based, block-level disk redirection that redirects physical disks in client computers to virtual disk images, sitting on network file servers. Client devices can each have their own virtual disk image files via one-to-one mapping, or multiple clients can share a single virtual disk image file. A client computer boots to the network, and the server recognizes the client based on its MAC address and mounts the appropriate virtual disk image file. This approach allows organizations to effectively deliver complete images each time the PC is powered up.[39]

The software technology for diskless PCs and remote boot is nascent and requires significant network bandwidth (most likely Gigabit Ethernet) as well as a persistent network connection, However, the advantage of this model is in centralizing servicing of the operating system as well as the ability to instantly upgrade or roll back the version of Windows on a system, which makes it particularly useful during OS migrations.[38]

Advantages

- *Rebooting Resets Machine To A "Good" State*. If a user's image on the client device becomes corrupted, a simple reboot can reset the machine to a "good" or "trusted"

state. Since OS streaming delivers the complete PC image to the client from a remote file server, the OS image can be maintained in a controlled and secure location.[16]

- *A Single Computer Can Do Different Things*. Client devices can each have their own virtual disk image files via 1-to-1 mapping, or multiple clients can share a single virtual disk image file. Servers and PCs can be re-provisioned on-demand to work with the concept of grid computing.[16]

Disadvantages

- *Network Connectivity Is Necessary*. Diskless PCs and remote boot solutions that do not cache applications and data on the local hard disk offer tighter control over user access to applications, but the applications cannot be used when the PC is disconnected from the network. Therefore, diskless PCs may not represent the best platform for client devices that are frequently disconnected from the network, such as laptop computers.[16]
- *Bandwidth Requirements*. Since a complete network boot occurs, Gigabit Ethernet networks need to be in place.

Dedicated Hardware With Local Management

Manual Installation

Manual installation, also commonly known as "sneakerware,"[40] is the traditional method for installing an application on a user's desktop and has been the method familiar to most PC users for the last 25 years. Software updates and security patches are either manually installed by disk or through download by the end user. For many scenarios, such as home office and small business environments, traditional management of desktop PCs had offered the best available combination of price, performance, and capabilities. For larger companies, however, manual installation of software and patches is less than an ideal solution.[16]

Advantages

- *Familiarity.* Every PC user is familiar with installing software by disk or by download on their home PC or laptop. In a corporate setting, IT personnel previously went from PC to PC to manually install applications from disk for each end user. Software updates and patches were many times left for the users to install, and while the process itself was not particularly daunting, providing the users with the instructions and the code did not ensure that the patches were in fact installed.

Disadvantages

- *Higher TCO*. The relatively low cost of PC hardware is often more than offset by the high cost of PC management and support. Ongoing PC management including deployment of applications, software updates, and security patches can be labor intensive because of the need to test and validate deployment for a wide variety of PC configurations. Likewise, lack of standardization and the need for support personnel to troubleshoot issues in person raise support costs.[14]
- *Application Corruption By Users*. The process of manually installing software on machines is time consuming and error prone. As such, the probability of a clean install is largely dependent on the skill of the operator, the window of time available to complete the installation, as well as the fatigue or alertness of the operator. Automated processes with minimum user intervention boast higher success rates as they remove much of the human error factors.[14] The end user can also delete necessary files from the computer, corrupting the application.

- *Lack Of Centralized Management.* Centralizing PC management is extremely difficult in the face of broadly distributed PC hardware and users who increasingly require access to their desktop environment from anywhere at anytime. Furthermore, PC desktops are notoriously difficult to standardize because of the variety of PC hardware and users' need to modify desktop environments.[14]
- *Lack Of Flexibility In Disaster Recovery*. Ensuring that data on PCs is successfully backed up and can be restored when PCs fail or files are lost is a significant challenge. Even when data is successfully backed up, the risk of PC theft threatens the security of important data. If a user's PC crashes or a business-critical application is corrupted, the user would have to wait until IT could fix the problem or build a new PC.[15,16]

The Future Of Desktop Delivery

Virtualization Technologies Can Be Combined To Create A Virtual Desktop Utility (VDU)

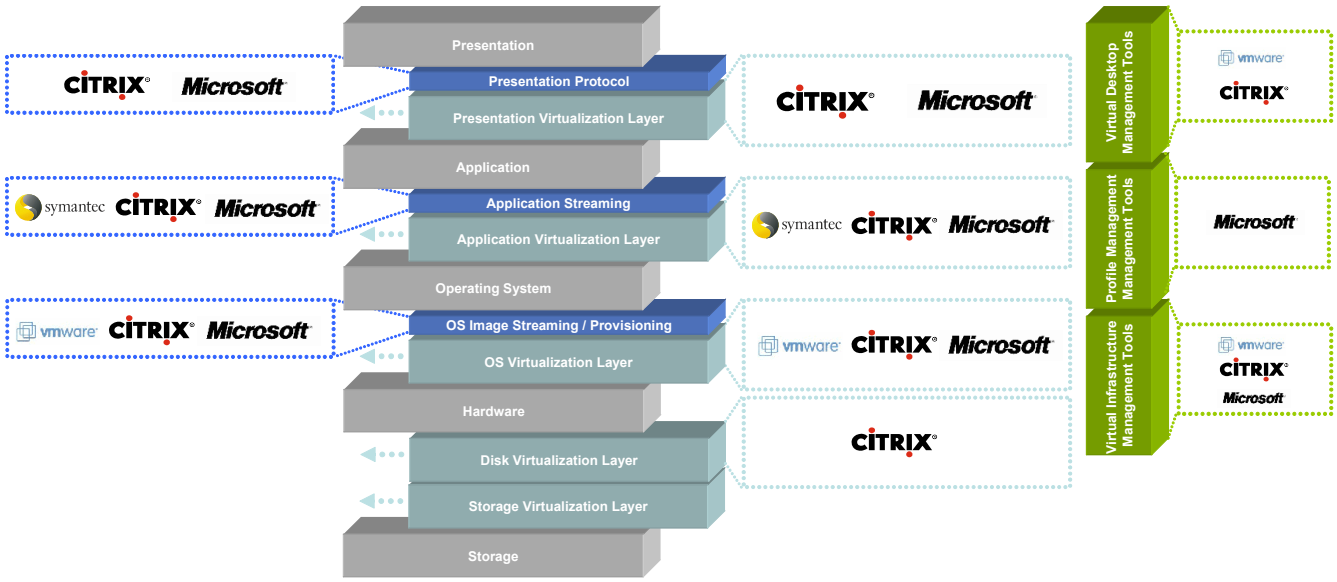
In the late 1990s, the proposed movement to thin-client terminals and server-based computing was founded on the basis of lowering the total cost of ownership of the end user's device through lower hardware and management costs, as the end user IT associated with managing that terminal is reduced significantly through the centralization of applications. Specifically, the total cost of ownership (TCO) of a Windows-based computing terminal equals slightly more than $2,500 as compared with the typically managed Windows desktop's TCO of more than $5,000.[13]

While the underlying cost savings and simplified management principles of thin computing were aligned with IT departments' goals, the standardized published desktops of traditional server-based computing architectures provided by companies such as Microsoft and Citrix Systems could not satisfy the desktop needs of all users—many of whom required more performance, data isolation, desktop personalization, and control (e.g., remote reboot).[7] Furthermore, two additional inhibitors to the adoption of terminal services historically were application compatibility with multi-user architectures (i.e., many applications are not designed for use in a multi-user environment and therefore create integration issues on terminal services platforms) and limited graphics support, namely the fact that graphically intensive applications or those with rapidly changing data on screen performed poorly. As such, widespread adoption of hosted desktops and thin-client computing has remained limited. However, with the current desktop management environment suffering from the aforementioned challenges, we believe that IT organizations—especially large enterprises—are seeking new technologies to reduce the cost and complexity of traditional PC management.

Conceptually rooted in the mainframe, the idea of "utility" or "grid" computing has been around for years, but implementation has not been widespread—particularly in the desktop computing environment. The utility computing paradigm aims to optimize IT investments by pooling resources and enabling the network to tap additional capacity on an as-needed basis to meet demand swings. Utility computing is the belief that information technology can be turned into a service—always on, on demand, and readily quantified. A key component of utility computing is the concept of virtualization for creating "pools" of on demand computing resources.

We believe that the concept of utility computing and, more specifically, the use of virtualization can be applied to the corporate desktop environment to improve performance, increase flexibility, and reduce operating and capital expenses. With respect to legacy desktop deployments, the operating system, application execution, and presentation layer are all self-contained, locally within a single device. In our opinion, combining virtualization technologies, which have historically been utilized independently for desktop management, to separate the four primary components of the traditional desktop infrastructure "stack"—the disk, operating system, application, and presentation layers—can produce a Virtual Desktop Utility (VDU) that parallels the theme of utility computing. Built upon desktop virtualization as a foundation, a Virtual Desktop Utility then incorporates functionality from other desktop management tools to offer many of the individual advantages of these legacy models, which we described in detail in the Desktop Management Models section of this report, in one, consolidated desktop delivery platform. (See Exhibit 17.)

Exhibit 17: Computing Stack And Virtualization Layers / Software Tools



Source: Credit Suisse

In a Virtual Desktop Utility environment, application components can execute on whichever backend systems they need in a grid-like way, and presentation components can be displayed and consumed wherever they are needed—either internally to the corporate intranet or externally for partners and/or remote access over the Internet.[16] The four virtualization technologies utilized in a virtual desktop utility include:

- *Presentation Virtualization*. Presentation or user interface virtualization technology is an abstraction layer that separates application execution from the interface or presentation layer. The presentation layer dictates how and where the end user interfaces with the application. With this technology, the application intelligence runs on one piece of hardware while a virtualized interface is presented to the user on any device at any location.

- *Application Virtualization*. Application virtualization technology is an abstraction layer that separates applications from the underlying operating system. Applications execute within "virtual sandbox" environments that protect the host operating system from being altered by the applications—enabling applications to run on any compatible computer without the need for installation and configuration. Within a virtual application sandbox, each application has its own set of configurations so they do not depend on the configuration of the host, a situation completely opposite traditional software deployment, and because of this, any application can run side-by-side with any other application without conflicts.[35]

- *Operating System Virtualization*. OS virtualization technology is an abstraction layer that decouples the operating system from the underlying physical hardware. Virtualization allows heterogeneous operating systems to run in isolation, side-by-side on the same physical machine. Each virtual machine has its own set of virtual hardware (e.g., RAM, CPU, NIC, etc.), upon which an operating system is loaded.[26]

- *Disk Virtualization*. With disk virtualization, clients do not need to have their operating system stored on locally attached bootable media to run (i.e., no hard drive or compact flash are required to boot an PC image).[41] The need for each user's operating system to have its own hard drive comes from the days where off-network usage was the norm and slow networks prevailed. Virtual desktops reside in the datacenter with gigabit Ethernet connections. Booting virtual machines over the network using the virtual

machine network interface card's built in PXE boot feature is a simple, straightforward solution to share a single boot image across large numbers of virtual desktops.[42] Virtual PCs can then run diskless, and the workload is streamed on-demand from network storage (e.g., NAS) to these stateless virtual machines. Utilizing disk virtualization enables IT departments to provision multiple virtual machines in the datacenter using a single desktop image—saving up to 90% of the storage capacity that would be required in maintaining complete images for each individual user.[15]

Decoupling the different layers of the client computing stack and reducing dependencies between the layers enable managing components atomically and servicing single instance of components centrally—while preserving the flexibility of components coming together dynamically to execute in either a local or centralized fashion. In addition to the virtualization layers, three enabling technologies are required for each associated encapsulation layer:

- *Presentation Protocol*. The presentation layer protocol lays down a specification for passing data between server and clients but is not bound to any one platform.
- *Application Streaming*. Application streaming solutions streams the necessary application files to the user's PC for the application to launch. The key point is that not all of the files are sent to the PC—only what is required to run that particular application is streamed.
- *OS Streaming / Provisioning*. OS streaming/provisioning streams the operating system, as well as certain applications if desired, from a central server—serving up a "golden PC image," which is accessed on-demand from the network each time the PC boots up.[41] Two forms of operating system streaming/provisioning exist: locally-cached and network-based. With locally-cached provisioning, a Microsoft Virtual Hard Disk (VHD) file, which contains the entire virtual machine operating system and the application stack in a single file, is saved to a machine's local media. Conversely, in the network-based model, which ties to the aforementioned disk virtualization layer, when a virtual machine is powered up, instead of booting from a local disk, the VM will boot from a virtual disk image hosted on network storage, and a provisioning server streams the assigned workload to the virtual machine. The primary difference is the issue of "stateful" (i.e., locally-cached) versus "stateless" provisioning (i.e., network-based on disk virtualization). Stateful provisioning is applicable to offline use of virtual desktops (e.g., laptops on airplanes), whereas stateless provisioning creates pooled, shareable resources and saves storage capacity.[43]

In addition to these virtualization components, profile management, desktop/session management, and virtual infrastructure management software is required to enable administration and management functions, including user mapping, allocation and de-allocation of desktops, and management of pooled desktops. Ultimately, we estimate that virtual desktops could lower the annual total cost of ownership of desktop computing by 40-50% versus high end workstations and 5-10% versus low end PCs.

Virtual Desktop Utility (VDU)

The Virtual Desktop Utility's form of desktop delivery, called "network centric management," is different than traditional client management architectures in that the authoritative copy of an OS and application packages are both created and maintained centrally. When a user logs in, the centralized system hosting an end user session accesses the OS and/or application packages over the network, executes the data locally, and presents the computing platform to the host device. Virtual Desktop Utility management enables a single-instance servicing model, where OS and application package configuration changes made in one central location can be made available to all users in a deterministic manner—a model that provides for an unprecedented level of agility and manageability with end users being able to access their OS and applications

from anywhere and IT being able to deploy software and desktop environments with a high level of agility and simplicity.[38]

We believe that the ability to pool desktop computing resources to eliminate the one user per Windows image paradigm represents one of desktop virtualization's key differentiators. Decoupling the user from a specific desktop environment requires the infrastructure to figure out which VM server has capacity for a new end user attempting to log in; discover the user's virtual disk files; start up a VM using those files; and then connect the user to that VM desktop image.[16]

In our opinion, the concept of a Virtual Desktop Utility (VDU) parallels the theme of utility computing and provides many of the individual advantages of legacy desktop management models previously described into one desktop delivery platform. Although a Virtual Desktop Utility (VDU) offers the broadest set of advantages to other models, some disadvantages exist depending on the end user type.

Advantages

- *Maintain Desktop User Experience*. The Virtual Desktop Utility centralizes desktop computing and storage resources into data centers and allocates a virtual machine to each end user. The processing, storage, and networking have been moved to the data center with access to applications, data, and their own personal computing environment within the user's virtual machine environment. In this strategy, each user has a dedicated computing resource running a single instance of the operating system, providing an enhanced, personalized desktop that can be remotely accessed through enterprise networks or the Internet.[23]

- *High Level Of Security.* Virtual Desktop Utility solutions let remote users access applications that reside in the corporate data center and adhere to company-approved security policies; intellectual property is not sent overseas where it is difficult to secure; and data resides on the corporate network where regulatory compliance can also be followed strictly. When a third-party contract is terminated or an employee leaves and network access is shut off, data still resides in the host country.[6]

- *Improved Price/Performance Versus Blade PCs*. The Virtual Desktop Utility architecture provides much better price/performance than the bladed PC architecture. While still providing the end user with a desktop experience, the virtual desktop solution does not maintain a one-to-one relationship between servers and users like the bladed PC architecture, which provides much more efficient utilization of computing resources.[16]

- *IT Cost Reduction*. A virtual desktop lowers the total cost of ownership of IT with reduced hardware depreciation costs, reduced costs associated with moves and changes; and reduced remote data center and business continuity charges. A Virtual Desktop Utility provides more effective cost management with increased centralization and utilization of large data centers. Overhead savings could also be realized with reduced desktop support headcount and reduced packaging and distribution charges.[24] Specifically, rapidly falling IT hardware prices have allowed corporations worldwide to significantly lower their internal IT capital expenditures. However, desktop computing acquisition costs typically account for only 20-30% of the total cost to the customer over the life of that hardware, while the remaining 70-80% consists of IT maintenance costs, such as moves/add/changes (MACs) of employees, repairs and fixes, and upgrades.[25] Furthermore, administering 250 servers costs significantly less to manage in both time and money than 5,000 desktop instances across an organization.

- *Increased Flexibility And Mobility*. A Virtual Desktop Utility architecture is capable of extending to remote sites without the need for extensive capital expenditures and provides the capability to efficiently provide external entities or newly merged entities access to applications without the need for application or server installation. The

centrally-managed virtual desktop system also enables simplified remote access and roaming for intra-office personal desktops for mobile employees.[24] The ability to connect to a single desktop image whether sitting at one's cubicle, logging in remotely, or traveling to a branch office through Citrix System's Smooth Roaming technology is a component of virtual desktop infrastructures that enables hot desking and worker mobility.

- *Improved Disaster Recovery*. Complete desktop environments are encapsulated inside virtual machines and maintained in the corporate data center where, in the event of a disaster, they can be instantly recovered and redeployed. Moreover, if one user's desktop crashes, it will not affect another user's desktop or application because it is running in a separate virtual machine.[26]

- *Increased Scalability*. Capacity planning and control is greatly enhanced when deploying applications from centralized virtual machines. Larger processor machines could be utilized to run numerous desktop images from the server room as opposed to deploying individual machines at each user's cubicle. Furthermore, partitioning a large server into VM images represents a more cost-efficient solution to PC blades. Efficient use of existing capacity enables scale to grow without additional investments at each incremental point of scaling.[24]

- *Simplified Operational Management*. Organizations with branch offices, remote workers, or offsite facilities can manage and standardize their desktop environments and applications in the corporate data center, where backups, upgrades, and complete maintenance can be performed from one central location. Virtual Desktop Utilities simplify software image updates—both operating system and application—because the entire software image resides on one file on the server.

- *Rapid Deployment Of Applications*. Within our vision of a Virtual Desktop Utility, new applications are applied once to the streaming server, and each user is updated instantly upon next invocation. This model also enables full and detailed accounting of licenses consumed, and unused licenses are automatically identified and re-harvested. Furthermore, an estimated 20-40% of Windows application installations conflict with each other.[19] However, unlike the compatibility problems associated with other application deployment solutions, our vision of a Virtual Desktop Utility—through its application virtualization technology—runs any off-the-shelf, legacy, or custom application without any modifications or regression testing.[26]

- *Reduced Support*. If a VM desktop image fails, that image is automatically replaced by another from the same, shared pool. Furthermore, based on our vision of a Virtual Desktop Utility's applications streaming and virtualization components, if an application crashes or a user deletes important application files, that application or the missing components can be automatically repaired through re-streaming to the VM image. Help desk calls and in-person support costs would be reduced through greater automation.

- *Desktop Customization/Personalization*. A virtual desktop infrastructure can provide a unique environment for each and every user, and each of these environments can be completely customized with different applications and settings without impacting other users. Furthermore, users can be granted more control of their own "virtual" desktop to allow them to install and modify applications if needed.[27]

- *Improved Compliance*. Transfer of malware through remote displays or thin-clients is rare. Furthermore, from a compliance standpoint, a virtual desktop infrastructure is ideal for offsite facilities used for development, call centers, back order processing, or other transaction-based tasks where confidential information and intellectual property can be securely stored and maintained in the corporate data center. Virtual PCs enable organizations to move sensitive data normally stored on a PC into the

corporate data center to maintain data integrity and meet regulatory compliance requirements (e.g., HIPAA, Sarbanes-Oxley, and Gramm-Leach-Bliley).[26]

Disadvantages

- *Data Center Must Be Built Out*. Initial capital investments to build out the virtual desktop infrastructure can also be rather high. Investments for data center servers, VMware or Microsoft virtualization solutions, as well as the IT administrators to manage the virtual desktop architecture, may represent a significant hurdle for some companies depending on their size and IT budgets.[16]

- *Lower User To Server Ratio Than Published Desktops*. A typical server is capable of hosting approximately 25-30 virtual desktops, whereas that same server could host 50-60 published desktops (e.g., via Presentation Server). If an end user does not require the personalization and performance of a virtual desktop (e.g., an administrative worker), a more-static published desktop might be more cost effective for these users, given that the hardware cost of published desktops at $100-120 per user is far less than $733-800 per virtual desktop user.

What About Offline And Desktop Virtualization?

To account for the growing presence of laptops in enterprise environments, we believe that a complete desktop virtualization solution needs to offer the ability to run corporately managed applications and PC images offline or, more accurately, when infrequently connected. Combining the paradigm of a Virtual Desktop Utility with client-hosted hypervisors and streaming/provisioning technology to enable users to seamlessly switch between online desktops and cached desktop images represents an ideal way to offer centrally-managed desktop environments to local users with LAN connectivity, as well as disconnected mobile and non-corporate remote users, via one architechture.[30]

Virtualization solutions enabling hybrid, online/offline modes of operation are especially useful for mobile employees—allowing employees to work with online applications and PC images even if disconnected from the backend server. For example, if a mobile employee intends to leave the corporate environment and travel on an airplane to a meeting across the country, a cached image of that user's virtual desktop, including the operating system, applications, and files, is copied onto a virtual machine created by a hypervisor on that employee's notebook before it is disconnected, and the virtual desktop image will then run locally inside of a virtual machine. Since the desktop environment is completely hosted on top of the operating system of a remote device (e.g., a laptop), the virtual desktop does not require a constant connection with a backend server. A major concern with offline deployment models is the security of the offline image. To address this concern, both the local VM image and any files that are extracted from the image to the local host environment must be encrypted. Advanced Encryption Standard (AES) encryption keys can be generated by the server and stored locally on the client.[44] Once connectivity to the backend server infrastructure is restored, both active synching with the server image, as well as versioning support for changes to user data and files, are then required to create a seamless end user experience with client side caching of a centrally-managed virtual desktop image and associated data.

For example, privately-held Kidaro offers a desktop computing solution for enterprise desktops and laptops that enables encapsulation of an entire desktop—operating system, applications, tools, and data—into a virtual machine that can operate as an isolated workspace whether or not the local machine was connected to the network. Kidaro's platform uses client-hosted desktop virtualization, which has the benefits of supporting mobile users and disconnected use.[45] Kidaro also offers a virtual desktop on a USB drive, named Kidaro ToGo, for providing users access to corporate applications and data anywhere and from any device. Kidaro ToGo could also be useful for maintaining a managed, secured desktop environment on top of non-corporate desktops. For users that need to work on corporate applications and to have their resources available whether they

are online or offline, instead of giving them a corporate laptop or building an entire server infrastructure for remote desktops, they could be provided Kidaro ToGo on a USB flash drive. This provides a corporate-managed and secured virtual corporate desktop, enabling authorized users to have all corporate applications and resources they need, on any endpoint. End users just plug the USB flash drive in to any workstation, regardless of hardware or user setup, and gain immediate access to corporate resources. They can even remove the Kidaro ToGo drive from one desktop and resume work on a different machine.[45]

One Size May Not Fit All

Advantages and disadvantages exist to local and central execution, shared and private environment, and local and central management models. Selecting one option over another (or employing a combination) is based on a mixture of both user and IT needs/requirements. (See Exhibit 18.) For example, all centralized execution options currently require a persistent network connection, and offline usability is limited. However, centralized execution is the only way to guarantee that applications and data always reside in the data center. This provides a level of control and security that is difficult to match in a local execution model.[38]

Exhibit 18: Desktop Deployment/Delivery Architectures

	Traditional PC (Manual Installation)	Automated Software Distribution	Presentation Virtualization	Virtual Desktop	Blade PC	Application Virtualization	Client Hosted Desktop	Virtual Disk PC
Description	High performance desktop	High performance desktop	Instant-on shared desktop	Versatile desktop that can be personalized	High performance desktop	Streaming application to mobile device	Desktop environment hosted by an existing PC or remote device	Desktop with centralized storage and local processing
Data Center Platform	None	Central server to install application package on desktops at disparate locations	Server running Windows Server OS and Windows Terminal Services	Virtual machines running Windows Desktop OS	Physical blade machines running Windows desktop OS	Server streaming virtualized applications to end user devices where they are processed locally	Server for the creation, packaging, and deployment of PC images	Server and SAN storage infrastructure to store OS images centrally and send data locally to be processed
Desktop Type	Private	Private	Pooled	Pooled or Private	Private	Pooled or Private	Private	Private
TCO/ROI	Worst	Weak	Best	Good	Weak	Better	Good	Good
Performance	Best	Best	Good	Good	Better	Good	Good	Weak
Execution	Local execution	Local execution	Centralized execution	Centralized execution	Centralized execution	Local execution	Local execution	Local execution
Used by	Currently utilized by almost all office workers	Currently the second most utilized method for office workers	Office workers who perform identical, routine tasks using a limited range of applications	Office workers who need a unique instance of a Windows OS	Office workers performing compute-intensive work who require rapid switching between many applications	Mobile employees who require a offline access to applications	Mobile and non-corporate remote users.	Office workers or non-employee users who needs quick and clean rebuilds of desktops
Examples	Currently utilized by almost all office workers	Currently the second most utilized method for office workers	Call-center staff, clerical workers, bank branch staff, retail centers	Marketing, financial, and other office workers; off-shore contract employees	Financial traders and engineers who require maximum computing performance and availability	Sales personnel, "road warriors," etc. who require offline access to applications	Home users, outsourced workers, and disaster recovery and supply chain partners	Test and development engineers, training classes, call-center staff, branch office staff, and conferences

Source: Citrix Systems, Credit Suisse

Based on our channel checks, virtualization technologies are becoming attractive for large enterprises in desktop computing environments, but SMB still favor traditional PCs. Even inside larger organizations we expect a mix of shared desktops, virtual desktops, and dedicated blades—based on the varying levels of capital cost efficiency, personalization, performance, and flexibility among the models. For example, a typical server is capable of hosting approximately 25-30 virtual desktops, whereas that same server could host 50-60 published desktops (e.g., via Presentation Server). However, while published desktops offer better capital cost efficiency, certain users with an organization may require the personalization and performance of a virtual desktop (e.g., knowledge workers, programmers, traders, etc.) versus a more static published desktop, which might be more applicable to employees in administrative roles.

Ultimately, we expect multiple solutions to be utilized by different organizations or even for diverse use cases within a single enterprise, which we believe benefits vendors with large product portfolios to enable multiple forms of desktop delivery through a cohesive, centralized platform.

Ultimately, we expect multiple solutions to be utilized by different organizations or even for diverse use cases within a single enterprise, which we believe benefits vendors with large product portfolios to enable multiple forms of desktop delivery through a cohesive, centralized platform.

Investment Analysis

Software

The availability of new software models (e.g., virtualization) facilitating the move toward a centralized desktop computing model is an important development within IT with significant benefits and opportunities with these technologies. Along with these opportunities come significant challenges in IT organizations overcoming cultural barriers to transition from traditional fat PC environments. However, despite these challenges, we believe IT organizations will experience a virtualization revolution on the client.[5]

Although the presentation virtualization market is relatively mature, the application and desktop virtualization markets are positioned at the very beginning of a high-growth period. The presentation virtualization software market is forecasted to grow from $1.225 billion in 2006 to $2.193 billion in 2011, representing a compound annual growth rate of 12.4%. The desktop virtualization market is expected to display the highest growth from a small base of $64.0 million in 2006 to $1.500 billion in 2011, representing a compound annual growth rate of 87.9%. The application and server virtualization markets are expected to grow at five-year compound annual growth rates of 41.7% and 27.0%, respectively.[5] (See Exhibit 19.)

Exhibit 19: Virtualization Software Forecast
US$ in millions, unless otherwise stated

	2003	2004	2005	2006	2007	2008	2009	2010	2011	CAGR (%) 2006-2011
Application Virtualization	3.8	12.0	20.0	35.0	55.0	80.0	110.0	150.0	200.0	41.7%
year-over-year growth		*215.8%*	*66.7%*	*75.0%*	*57.1%*	*45.5%*	*37.5%*	*36.4%*	*33.3%*	
Desktop Virtualization	2.3	5.8	19.0	64.0	182.0	440.0	750.0	1,190.0	1,500.0	87.9%
year-over-year growth		*152.2%*	*227.6%*	*236.8%*	*184.4%*	*141.8%*	*70.5%*	*58.7%*	*26.1%*	
PC Disk Virtualization	1.0	2.5	6.0	11.0	18.0	60.0	100.0	160.0	233.0	84.2%
year-over-year growth		*150.0%*	*140.0%*	*83.3%*	*63.6%*	*233.3%*	*66.7%*	*60.0%*	*45.6%*	
Presentation Virtualization	959.0	1,059.7	1,137.8	1,225.0	1,372.0	1,554.0	1,762.0	1,976.0	2,193.4	12.4%
year-over-year growth		*10.5%*	*7.4%*	*7.7%*	*12.0%*	*13.3%*	*13.4%*	*12.1%*	*11.0%*	
Server Virtualization	205.0	560.5	819.0	1,033.7	1,366.6	1,854.6	2,506.8	3,047.2	3,412.1	27.0%
year-over-year growth		*173.4%*	*46.1%*	*26.2%*	*32.2%*	*35.7%*	*35.2%*	*21.6%*	*12.0%*	
Virtualization	**$1,171.1**	**$1,640.5**	**$2,001.8**	**$2,368.7**	**$2,993.6**	**$3,988.6**	**$5,228.8**	**$6,523.2**	**$7,538.5**	**26.1%**
year-over-year growth		***40.1%***	***22.0%***	***18.3%***	***26.4%***	***33.2%***	***31.1%***	***24.8%***	***15.6%***	

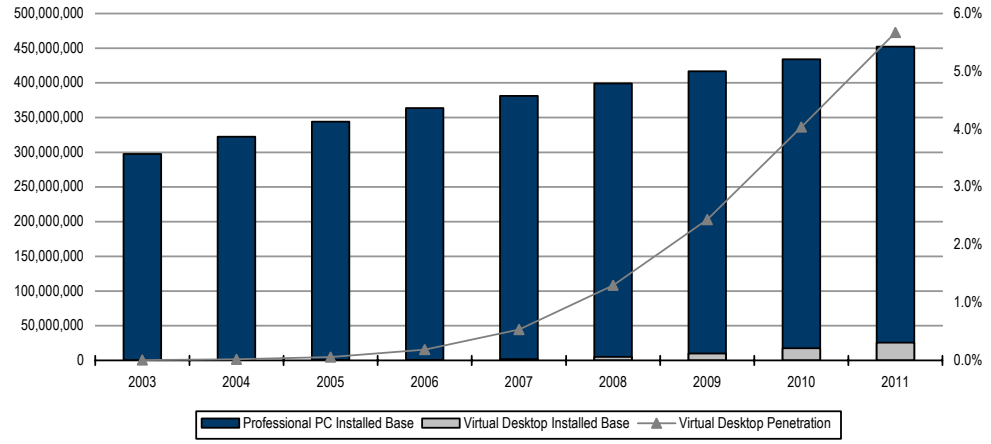
Source: IDC, Credit Suisse estimates

Virtualization has been one of the largest buzzwords in the IT community and many organizations continue to invest in virtualization technologies to improve the operation of and services provided by their datacenters. These solutions improve IT environments in terms of security, resiliency, disaster recovery, and manageability, and as such, various virtualization strategies have garnered a lot of interest. To date, the majority of the adoption has occurred in the server and presentation virtualization space with virtual desktop solutions primarily deployed in testing environments. We expect presentation virtualization to represent a slowly decreasing majority of revenue within the virtual client computing framework. In fact, as desktop and application virtualization mature, the combination of the two will begin to rival presentation virtualization solutions in terms of dollars spent.[5]

To provide a sense of penetration of virtual desktops implied by the market growth expectations detailed in Exhibit 19, we performed a tops-down analysis of the installed base of desktop PC among professional users. The estimated installed base of professional desktop PCs is forecasted to reach 381.3 million by year end 2007 and to grow to 452.1 million in 2011. In our analysis, we assume a $200 per virtual desktop average selling price, a 40% discount off of list pricing for both customer and channel

discounts, and an annual maintenance cost of 20% of the list license prices including a 25% price break for customer and channel discounts. Utilizing these assumptions, we estimate that a desktop virtualization software market reaching $1.5 billion in revenue by 2011 would translate into an installed base of approximately 25.6 million virtual desktops—representing approximately 5.7% penetration of the professional desktop PC installed base. (See Exhibit 20.)

Exhibit 20: Professional Desktop PC Versus Virtual Desktop Installed Bases – Implied By Desktop Virtualization Software Market Forecast In Exhibit 19



Source: IDC, Gartner, Credit Suisse estimates

Therefore, while much of Wall Street has become fixated on the growth potential of the server virtualization market, we believe that desktop virtualization solutions are poised for significant growth and represent an end market that could eventually surpass server virtualization software, given the relatively low penetration levels that resulted from the market sizing analysis in Exhibit 19 and Exhibit 20.

Ultimately, we believe that software vendors offering the broadest, yet most integrated set of desktop delivery solutions will be best-positioned to dominate this emerging market. From a stock perspective in the software industry, we view Citrix Systems followed by VMware as the vendors most likely to benefit from increased adoption of server-based and virtual desktop technologies.

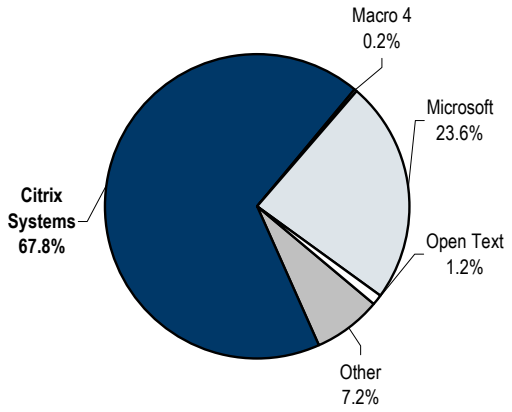
Competitive Analysis

While desktop virtualization represents, in our opinion, the most compelling form of desktop delivery and management that most closely resembles the traditional PC experienced from an end user perspective, we expect a "mixed environment" to exist—even within organizations utilizing virtual desktop technologies. Advantages and disadvantages exist to local and central execution, shared and private environment, and local and central management models. Selecting one option over another (or employing a combination) is based on a combination of both user and IT needs/requirements.

Additionally, the desktop virtualization market represents the combination of many of the underlying technologies of both presentation and server operating system virtualization software solutions, and Citrix and VMware maintain the vast majority of the market share of these two sub-segments of virtualization software—with Citrix dominating the presentation virtualization market and VMware dominating the server virtualization market. (See Exhibit 21 and Exhibit 22.) While both companies will attempt to leverage their relative dominant positions in their respective core markets to enter into the desktop virtualization market, we believe that software vendors offering the broadest, yet most-integrated set of desktop delivery solutions will ultimately be best-positioned to dominate this emerging market.

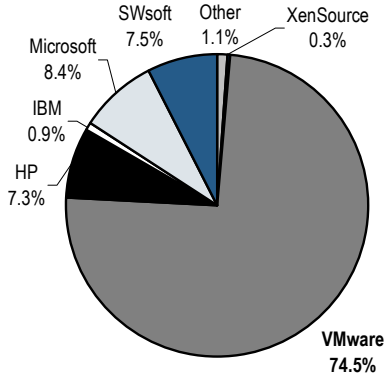
The desktop virtualization market represents the combination of many of the underlying technologies of both presentation and server operating system virtualization software solutions, and Citrix and VMware maintain the vast majority of the market share of these two sub-segments of virtualization software—with Citrix dominating the presentation virtualization market and VMware dominating the server virtualization market.

Exhibit 21: Presentation Virtualization Market Share



Source: IDC

Exhibit 22: Server Virtualization Market Share



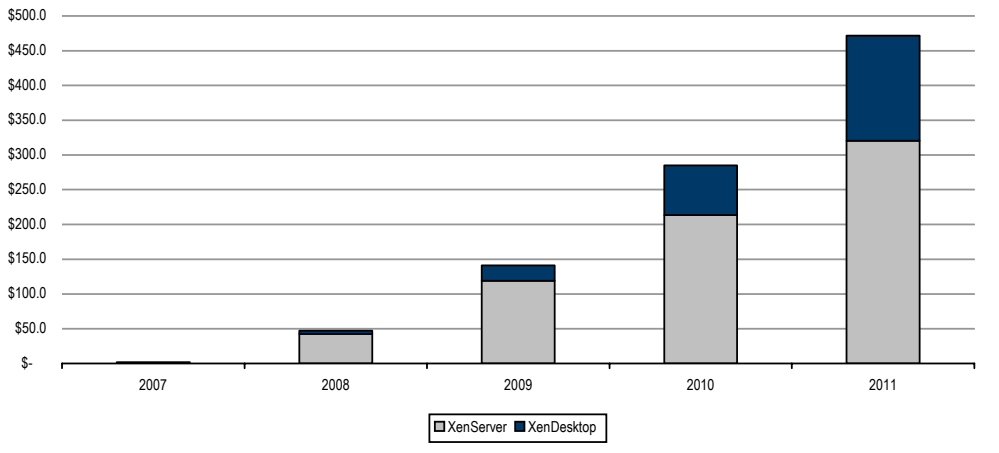
Source: IDC

Based on these factors, we view Citrix as the best-positioned vendor to capitalize on the emerging desktop virtualization market, given the breadth and depth of its application and desktop delivery product portfolio, as well as the installed base of organizations utilizing Presentation Server. More than 70 million end users already utilize Citrix Presentation Server to run applications on a central terminal server and then provide end users with desktop access to that server, and we believe that the company's soon-to-be-released Citrix XenDesktop solution will represent the most feature-rich desktop virtualization software on the market that also most closely parallels the Virtual Desktop Utility model.

Citrix Systems

Given the breadth and depth of its extensive application and desktop delivery product portfolio (including the soon-to-be-released Citrix XenDesktop solution), as well as the installed base of organizations utilizing Presentation Server, we view Citrix Systems as best-positioned vendor to dominate the emerging desktop virtualization market—driving significant potential upside to our long-term forecasts.

Exhibit 23: Credit Suisse XenDesktop And XenServer Revenue Forecast
US$ in millions, unless otherwise stated



Source: Credit Suisse estimates

Specifically, we forecast Citrix's XenDesktop revenue to grow to approximately $150 million by 2011, equaling 5.6% of our $2.68 billion revenue estimate for the company as a whole and only 10.0% of the desktop virtualization market. (See Exhibit 23.) However, if Citrix could capture one-third of the $1.5 billion desktop virtualization market, this revenue

contribution would drive more than $350 million upside to our current estimates. Applying our forecasted average corporate operating margin of 25.0% in 2011 for the company to this incremental revenue would produce an incremental $0.34 in earnings per share.

Furthermore, while many investors remain uncertain regarding the potential adoption of XenSource's server virtualization solutions, our combined forecast for both XenDesktop and XenServer revenue (including both license and maintenance revenue) equals $471.7 million in 2011. Therefore, if Citrix could capture one-third of the $1.5 billion desktop virtualization market, this revenue contribution would exceed our combined desktop and server virtualization revenue forecast by $28.3 million. As a result, we believe that investors could include no revenue contribution in their Citrix models from XenSource's server virtualization solutions that compete against VMware's core VI3 platform but still not be concerned about their long-term revenue growth forecasts. In fact, any adoption of XenServer virtualization solutions could be viewed as a call option on overall desktop and server virtualization revenue over the next five years.

In addition, we currently forecast a five-year compound annual revenue growth rate of 18.8% for Citrix through 2011—far below the expected compound annual growth rate of the company's end markets at 24.1%. (See Exhibit 24.)

Exhibit 24: Citrix System's Addressable Market
US$ in millions, unless otherwise stated

	2006	2007	2008	2009	2010	2011	CAGR (%) 2006-2011
Application Delivery Controller	932.6	1,173.0	1,607.4	2,021.7	2,291.0	2,527.2	22.1%
year-over-year growth	*28.1%*	*25.8%*	*37.0%*	*25.8%*	*13.3%*	*10.3%*	
Application Virtualization	35.0	55.0	80.0	110.0	150.0	200.0	41.7%
year-over-year growth	*75.0%*	*57.1%*	*45.5%*	*37.5%*	*36.4%*	*33.3%*	
Desktop Virtualization	64.0	182.0	440.0	750.0	1,190.0	1,500.0	87.9%
year-over-year growth	*236.8%*	*184.4%*	*141.8%*	*70.5%*	*58.7%*	*26.1%*	
PC Disk Virtualization	11.0	18.0	60.0	100.0	160.0	233.0	84.2%
year-over-year growth	*83.3%*	*63.6%*	*233.3%*	*66.7%*	*60.0%*	*45.6%*	
Presentation Virtualization	1,225.0	1,372.0	1,554.0	1,762.0	1,976.0	2,193.4	12.4%
year-over-year growth	*7.7%*	*12.0%*	*13.3%*	*13.4%*	*12.1%*	*11.0%*	
Remote Access Services	94.5	131.9	173.8	219.9	269.8	321.1	27.7%
year-over-year growth	*51.9%*	*39.6%*	*31.8%*	*26.5%*	*22.7%*	*19.0%*	
Remote Control Services	100.9	125.9	153.9	184.3	215.7	247.3	19.6%
year-over-year growth	*33.0%*	*24.8%*	*22.2%*	*19.8%*	*17.0%*	*14.6%*	
Server Virtualization	1,033.7	1,366.6	1,854.6	2,506.8	3,047.2	3,412.1	27.0%
year-over-year growth	*26.2%*	*32.2%*	*35.7%*	*35.2%*	*21.6%*	*12.0%*	
SSL VPN Equipment	281.1	340.3	406.5	467.5	519.9	554.8	14.6%
year-over-year growth	*19.4%*	*21.1%*	*19.5%*	*15.0%*	*11.2%*	*6.7%*	
WAN Optimization Controller	585.6	826.0	1,216.3	1,633.0	1,996.3	2,195.2	30.2%
year-over-year growth	*14.1%*	*41.1%*	*47.2%*	*34.3%*	*22.2%*	*10.0%*	
Web Conferencing	935.9	1,130.1	1,371.4	1,636.6	1,904.5	2,190.2	18.5%
year-over-year growth	*19.9%*	*20.7%*	*21.4%*	*19.3%*	*16.4%*	*15.0%*	
Total Market	**$5,299.3**	**$6,720.8**	**$8,917.9**	**$11,391.8**	**$13,720.3**	**$15,574.2**	**24.1%**
year-over-year growth	***20.5%***	***26.8%***	***32.7%***	***27.7%***	***20.4%***	***13.5%***	

Source: IDC, Gartner, Credit Suisse estimates

Will Desktop Virtualization Cannibalize Or Complement Presentation Server?

While desktop virtualization represents a new, emerging desktop management technology that we expect to broaden the use of thin computing architectures, some investors have been concerned that sales of Citrix XenDesktop could cannibalize Presentation Server sales. While desktop virtualization could serve as a replacement for Presentation Server in certain deployment cases (e.g., a customer utilizing Presentation Server to deliver published desktops to thin-clients inside of an organization), we believe that Presentation Server's application publishing and streaming capabilities can complement desktop virtualization solutions by separating desktop delivery from application delivery.

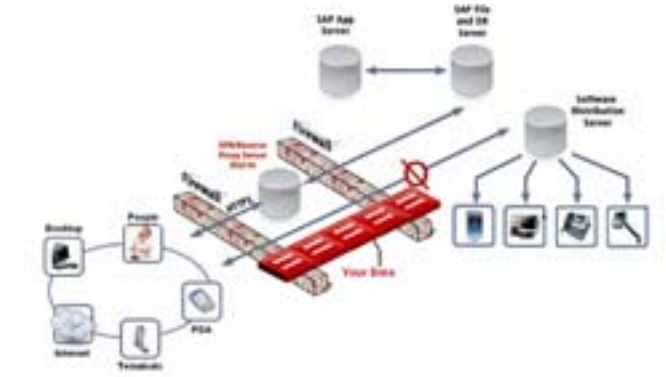
While desktop virtualization could serve as a replacement for Presentation Server in certain deployment cases (e.g., a customer utilizing Presentation Server to deliver published desktops to thin-clients inside of an organization), we believe that Presentation Server's application publishing and streaming capabilities can complement desktop virtualization solutions by separating desktop delivery from application delivery.

Specifically, separating desktop and application delivery eliminates application conflicts and optimizes system performance—creating a light, flexible architecture that delivers applications, desktops, and data to any user in any location at the lowest cost. Utilizing virtualization layers for the delivery of applications enables IT to provide pristine desktops and applications to users for optimal performance and 100% application compatibility.[15]

Furthermore, presentation layer virtualization is attractive for delivering client/server applications to end user devices—even if the device is a virtualized desktop—given that Presentation Server not only centralizes the processes of large footprint applications but also eliminates the complexities of deploying, managing, updating, and securing a vast array of client software on each individual user's access device. Specifically, Presentation Server enables users to run certain client/server applications (e.g., ERP or CRM applications) where it would be infeasible or, at least, less cost efficient to run on a user's desktop—even if that desktop is virtualized onto a centralized server.[46]

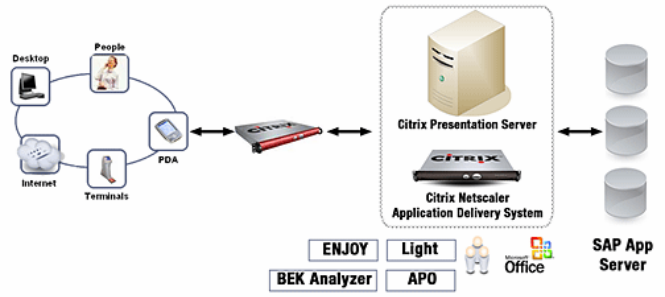
For example, companies wishing to obtain the benefits of the latest mySAP enterprise resource planning (ERP) solution face several challenges. Upgrading desktop hardware, operating systems and networks to support the right SAP GUI user interface results in additional costs. Furthermore, delivering a powerful application like SAP can affect network performance, depending on the specific SAP user interface, SAP business transactions and SAP ERP modules. (See Exhibit 25.) Citrix Presentation Server streamlines the delivery of mySAP client software and accelerates performance by hosting application components centrally.[47] (See Exhibit 26.)

Exhibit 25: Traditional SAP Deployment



Source: Citrix Systems

Exhibit 26: Presentation Server SAP Deployment



Source: Citrix Systems

In a Presentation Server environment, all software components reside and execute on servers in the data center. SAP GUI software can be centrally installed and made available in a fraction of the time and cost to implement on physical or virtual desktops across a large and/or dispersed user base. Once installed on the Citrix Presentation Server, the SAP GUI can be pushed out to other servers and made instantly available to all users simultaneously. When users log back in, they automatically receive all system enhancements without having to change anything on their personal devices. Furthermore, because the client/server application executes on Presentation Server, only minimal data

is sent over the network, and bandwidth needed to access the application can be reduced significantly—saving money and improving performance over existing networks.[47]

When utilizing both Presentation Server and desktop virtualization, a single instance of the client application is installed on a Presentation Server, and the application executes entirely on the server while its interface is displayed on the user's virtual desktop. Keeping client-server applications under the centralized control of IT administrators reduces the costs of managing separate clients and applications on every user's virtual desktop.[47]

Additionally, by having Presentation Server present applications onto virtual desktops, desktop images can be reduced in size—reducing storage requirements. Additionally, capacity planning is greatly enhanced when deploying applications from centralized terminal servers as opposed to individual virtual desktop images, as efficient use of existing capacity enables the ability to scale without additional investments at each incremental point of scaling of a virtual desktop.[11]

Ultimately, Presentation Server's centralized application provisioning capabilities give customers with large Presentation Server farms one central location to stage the latest versions of all Windows, desktop, and client-server applications, enabling IT to more easily provision new applications to physical or virtual desktops. As a result, the delivery and maintenance of applications across mid-to-large enterprises is greatly simplified—even when that organization is utilizing virtual desktops.[15] Based on the synergies between Citrix XenDesktop and Presentation Server, we believe that the company will offer multiple versions of Citrix XenDesktop (i.e., Advanced, Enterprise, and Platinum) incorporating a mixture of the various virtualization technologies in its product portfolio—including Presentation Server. (See Exhibit 27.)

Exhibit 27: Potential XenDesktop Editions

	Connection Broker	Xen Hypervisor	XenCenter	Provisioning Server	Presentation Sever	Application Streaming	Password Manager	EdgeSight	Access Gateway
Advanced	X	X							
Enterprise	X	X	X	X	X	X			
Platinum	X	X	X	X	X	X	X	X	X

Source: Credit Suisse

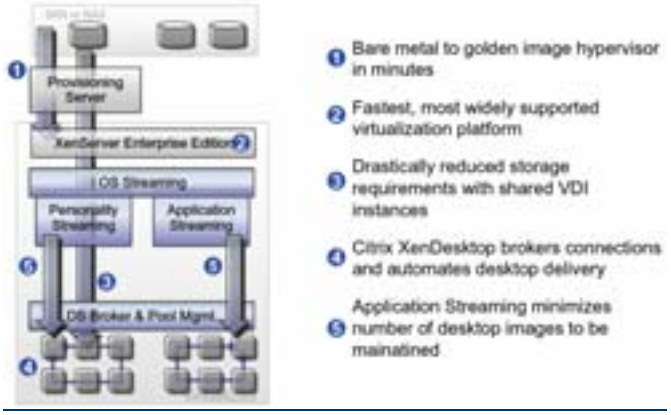
While many complementary features exist between Citrix XenDesktop and Presentation Server, the two solutions overlap one another in some existing deployments of Presentation Server. For example, a customer might already utilize Presentation Server to deliver published desktops to thin-clients inside of its organization. Given the enhanced application compatibility and personalization functionality of desktop virtualization, that customer might find Citrix XenDesktop the more appropriate solutions for some, or potentially all, of its user base. While this scenario illustrates the potential cannibalization of Presentation Server by Citrix XenDesktop, we believe that desktop virtualization will extend the use of thin computing deeper into the existing user base and across new customer sets. Therefore, although Citrix XenDesktop may be the more appropriate solution in certain instances as compared with Presentation Server, we believe that desktop virtualization ultimately expands the addressable market served by Citrix Systems.

Citrix XenDesktop

During the company's 2007 App Delivery Expo, Citrix XenDesktop was unveiled, and we expect Citrix to officially release the solution during the first half of 2008. Mirroring our vision of a Virtual Desktop Utility, the concept behind XenDesktop is that IT departments would utilize XenSource's hypervisor and virtual infrastructure management tools to divide a server into multiple client virtual machines. Administrators would then create a small set of simplified OS images that store no user state data via Provisioning Server. Applications are either built into the images or delivered on the fly with Presentation Server or Streaming Server when the user logs in. All user data and application settings would be stored and managed separately. Based on Citrix's ICA protocol, SpeedScreen ensures that screen images on XenDesktop clients are presented at up to twice the speed of

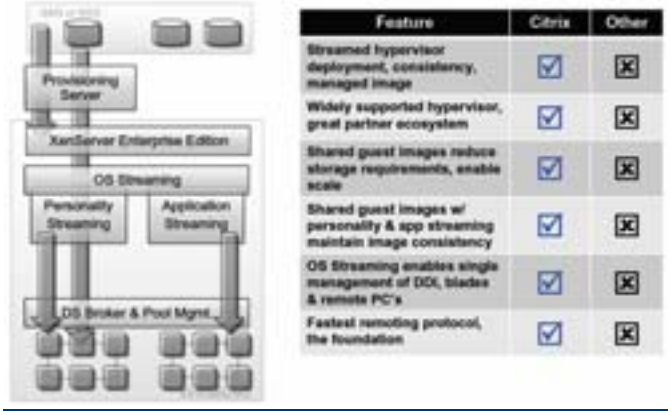
competing technologies to ensure that performance will at least match that of a traditional individual PC system. When the user logs out, the virtual machine image is whipped clean and all user data and application settings are stored back onto the SAN. In this model you only need to store the base images and the user profile data, as opposed to complete desktop images.[15]

Exhibit 28: Citrix XenDesktop Architecture



Source: Citrix Systems

Exhibit 29: Citrix XenDesktop Differentiation



Source: Citrix Systems

The ability to pool desktop computing resources to eliminate the one user per Windows image paradigm represents one of desktop virtualization's key differentiators. Decoupling the user from a specific desktop environment requires the infrastructure to determine which VM server has capacity for a new end user attempting to log in; discover the user's virtual disk files; start up a VM using those files; and then connect the user to that VM desktop image. While these processes are undoubtedly complex, Citrix Systems actually has experience managing many of these issues in the Presentation Server world, which we believe can be ported to a virtual desktop environment.[16]

Citrix XenDesktop, which is the combination of Citrix Desktop Server, XenServer, and Citrix Provisioning Server, delivers centrally-managed, virtual desktops to users inside of the corporate firewall. The components of Citrix XenDesktop include:

- *Xen Hypervisor*. The first step of the process is to build a virtualized server utilizing hypervisor technology. The virtualization layer divides the server into numerous individual virtual machines with each VM running the Windows operating system and the necessary applications to be delivered to the end users based on their division or function (i.e., outsourced programmers in India require different applications than a financial trader).[16,27]
- *XenCenter*. XenCenter offers real time and trended graphing of virtual machine and total server performance metrics including CPU, memory, plus disk and network I/O.[15]
- *XenMotion*. XenMotion enables several users to share a common pool of desktops that are allocated on-demand and then returned to the pool after logoff. User personalization is captured and applied for a consistent familiar experience each time.
- *Desktop Sever*. Desktop Server Session Manager manages the pools of Windows images for common users and communicates with a Desktop Server database that contains connection information for the pooled desktop images available on a virtualized server. As pooled resources are employed, Desktop Server will note in its data warehouse that a particular desktop image is "in use" and unavailable, and as such, the next user attempting to connect will be redirected to an available virtual machine image.[48] Once a session is closed, Desktop Server can have the data from the VM stored, and the VM can be wiped clean and be sent back into the pool.[27]

- *Independent Computing Architecture (ICA) Stack*. One of the issues with the existing forms of other desktop virtualization solutions is the inherent limitations of Microsoft's Remote Desktop Protocol (RDP). When a user connects over RDP from India to London, for example, to a London Windows desktop image, all works well until latency is introduced (something near 500 milliseconds). In comparison, ICA offers more robust performance than RDP over latent networks and, therefore, is more useful for branch office, remote access, and outsourcing deployments. Additionally, ICA provides stronger graphical performance and multi-monitor support than RDP.[16] Citrix administrators, with whom we have spoken, believe that decoupling the ICA stack and having it reside on the Windows image represents the most appropriate solution to the latency problem. In our opinion, enabling the key differentiating features of ICA versus RDP, such as SpeedScreen, Session Reliability, virtual channel control, etc., provides Citrix Systems with a competitive advantage in the virtual desktop market—especially in large, multinational organizations. An uncoupled ICA stack will be available with the release of Desktop Server 2.0 in the fall of 2007 to provide access to the virtual desktop image, as opposed to the Window's built-in RDP client.

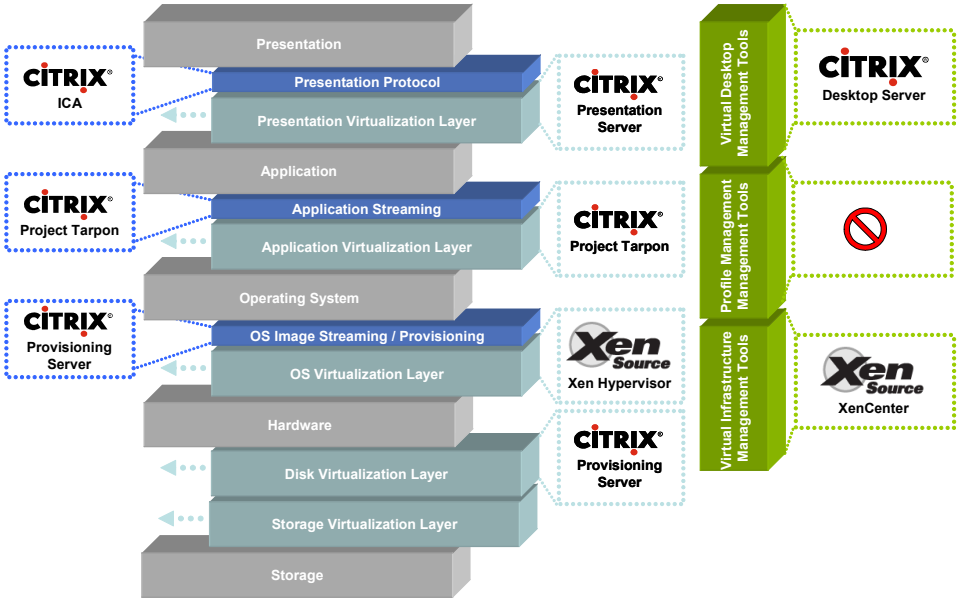
- *Provisioning Server*. The overall dependency on vast amounts of SAN storage is one of the biggest obstacles to adoption of desktop virtualization, as entire PC images must be stored. Provisioning Server, formerly known as the Ardence Software-Streaming Platform, provisions multiple virtual machines in the datacenter using a single desktop image—saving up to 90% of storage capacity that would be required from competing virtual desktop solutions.[15] Specifically, Provisioning Server can deliver a complete PC image called vDisks, sitting on network file servers to a virtual machine. When a virtual machine boots, it authenticates to the network to determine which PC image gets remotely loaded to that virtual machine. This approach allows organizations to effectively deliver complete images each time the PC is powered up or a virtual machine is created. Ardence allow a VM to pre-fetch disk blocks from a disk image file across a network, allowing the virtual machine to boot from that disk image before the image is 100% copied to the player machine. Essentially, maintaining a stateless operating system image, which can later be personalized through application streaming based on user profiles, reduces image sizes. With reduced image sizes, less storage is required as compared with an architecture in which the user's data and personalized disk image are saved back to a storage area network (SAN).[16] A deployment of 5,000 users each with a five-gigabyte Windows XP boot disk would consume twenty-five terabytes of shared storage. A shared image strategy not only saves on storage but also provides a single location to patch and deploy applications, as changes propagate to virtual desktops the next time they boot.[42]

Future Directions Of Citrix XenDesktop

As we first highlighted in our "RDB Marks Foray Into Desktop Virtualization" on August 15, 2006, combining virtualization technologies to separate the four primary components of the traditional desktop infrastructure "stack"—disk, operating system, application, and presentation—can produce a Virtual Desktop Utility (VDU) that parallels the theme of utility computing.

We believe that through combining Presentation Server's unmatched application publishing capabilities and ICA protocol with the soon-to-be-released XenDesktop solution, as well as Provisioning Server and Streaming Server, Citrix is uniquely positioned to satisfy nearly 100% of all desktop user requirements and deployment scenarios with specific solution sets for each scenario's unique requirements and to deliver an integrated solution closest to a Virtual Desktop Utility model. (See Exhibit 30.)

Exhibit 30: Citrix System's Product Portfolio Of Virtualization Technologies And Tools



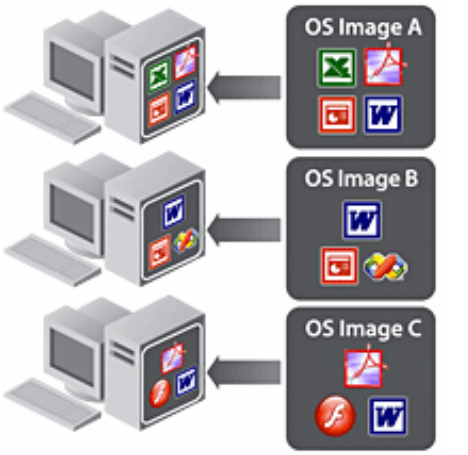
Source: Credit Suisse

Therefore, we believe that Desktop Server versions 1.0 and 2.0 and Citrix XenDesktop mark only the beginning of Citrix Systems' advances in the virtual desktop market. Specifically, we believe that the company will offer multiple versions of XenDesktop (i.e., Advanced, Enterprise, and Platinum as detailed in Exhibit 27) incorporating a mixture of the various technologies for desktop virtualization in its product portfolio, the highest-end version of which we expect to deliver functionality closely paralleling a Virtual Desktop Utility model. In our opinion, several advances that could increase the value of Citrix XenDesktop over time include:

- *Web Interface*. When a user wishes to establish a connection to a backend virtual desktop, the user connects to Presentation Server through Web Interface to the published ICA client, which communicates with the ICA software on the VM image.
- *Presentation Server*. Virtual desktop images can be reduced in size by having Presentation Server applications presented to those virtual desktops in a server-based computing structure.
- *Application Streaming*. Citrix's application streaming technology derives from the Application Isolation Environment (AIE) feature released in Presentation Server 4.0. AIE provides a virtualized environment for access to files, registries, and named objects, which enables applications that are incompatible with each other to run simultaneously. AIE also allows applications that were previously unable to run in a multi-user environment to run on Presentation Server.[22] We believe that Streaming Server's virtualization and streaming technologies could serve as key components of a Virtual Desktop Utility architecture. For example, when a user logs in, XenDesktop would provision an available VM through virtual machine management software tools and instruct Citrix's application steaming technology to load that user's relevant applications based on the user profile stored in Presentation Server. When a user logs out, the applications, which never actually made changes to the Windows registry, DDLs, and other shared settings but rather ran on top of an application isolation environment, can be "thrown out;" the user's data and disk image including personal network shares (e.g., My Documents, etc.) can be saved back to a storage area network (SAN);[8] and the VM which still maintains a clean operating system (since the applications were never installed on the operating system and, as such, never altered any registry files that could create future application conflict) can be added back into

the pool to be re-provisioned to any user regardless of their department, function, or application requirements. Streaming Server redirects registry keys, files, folders, and some system objects from common locations to isolated locations (i.e., applications are still installed and write to the registry and the file system but in isolated environment).[49]

Exhibit 31: Traditional Image Management



Source: Microsoft

Exhibit 32: Image Management With Streaming Server

Source: Microsoft, Credit Suisse

- *EdgeSight*. While keeping track of pooled VM resources and their availability represents a key feature of Desktop Server, we believe that more robust administration tools will be required to fully leverage the Virtual Desktop Utility vision. For many organizations, identifying the root cause of virtual server problems and rectifying them remains largely a manual process. As the number of virtual machines in the data center increases, solving those problems in an automated way becomes more urgent.[50] As such, we expect Citrix Systems integrate the EdgeSight technology from its acquisition of Reflectent into its XenDesktop solution to extend monitoring and management capabilities to virtual desktops.

- *Citrix Access Gateway with Advanced Access Control*. Since Desktop Server will be most attractive in implementations for outsourced labor (e.g., software programmers), ensuring secure remote access is a necessity. The basic idea is that the end user needs a simple yet secure method for accessing the VM image without requiring client software on that end device, such as an IPSec VPN client.[27] The end user can connect to the Citrix Access Gateway to establish a clientless SSL session into Presentation Server. The Advanced Access Control (AAC) feature ensures endpoint integrity before granting access to the network and continuously scans endpoints to ensure that the requisite antivirus and personal firewall programs are running, and if they are not, then access to the network is denied. The unique Advanced Access Control option provides organizations with the ability to grant the same users different levels of action rights (i.e., view, print, edit, save, etc.), depending on their access scenario (i.e., who they are, where they are, the device they are using, how it is configured, and the connection through which they are accessing the network).[15]

- *XenSource / "Offline Ardence" / Active Synching & Versioning*. Running a virtual machine on the desktop is unique in that an entire desktop environment can be created and managed centrally but is then run on top of an already-existing desktop environment hosted by a PC or remote device through the use of a hypervisor layer. Based on our industry checks, Ardence has been working on an offline solution, which would enable desktop images to be streamed into a virtual machine (e.g., Xen hypervisor) hosted on an end point and then be run locally—a scenario that we view as

key for extension of virtual desktop technology for disconnected use. In fact, on September 11, 2007, Citrix announced plans to extend its support of Microsoft's VHD format in the future to include operating system streaming to both servers and desktops, and XenSource also supports VHD as its native runtime format for virtual machines. Since the desktop environment is completely hosted on top of the operating system of a remote device (e.g., a laptop), it does not require constant connection with a backend server. For example, a corporate user with a laptop would utilize a virtual desktop—hosted on a back-end server with the OS image and user-specific applications having been streamed to it via Ardence and Streaming Server, respectively, and brokered by XenDesktop—when that individual had consistent network connectivity (i.e., working on the corporate LAN, connecting remotely via a high-speed data service, etc.). However, if that user needed to work offline (i.e., traveling on a plane from New York to San Francisco), that virtual desktop image could be streamed onto a XenSource hypervisor via the forthcoming offline version of Ardence's streaming technology. Combining the paradigm of a Virtual Desktop Utility with client hosted hypervisors and streaming technology to enable users to seamlessly switch between online desktops and cached desktop images represents an ideal way to offer centrally-managed desktop environments to local users with LAN connectivity, as well as disconnected mobile and non-corporate remote users, via one architechture.[30] With client side caching of a centrally-managed virtual desktop image and associated data, active synching with the server image, as well as versioning support for changes to user data and files, are required once connectivity to the backend server infrastructure is restored to create a seamless end user experience.

- *Profile Management Tools*. As the number of applications increases and the diversity of users and accessing devices expands, IT's primary objective of getting the right applications to the right users becomes increasingly challenging. To compound the problem, recent new application and desktop delivery technologies such as virtual desktops and streaming add to this burden by increasing the management demands on the IT department. These new delivery technologies also create issues for end users as they are forced into different working environments depending on the delivery mechanism being used, the applications they need to use, and the accessing device they are using. In order to truly deliver a Virtual Desktop Utility, we believe that Citrix requires additional profile management tools to provide a consistent and seamless environment for end users across a range of application delivery mechanisms and managed through a centralized, fully integrated console.

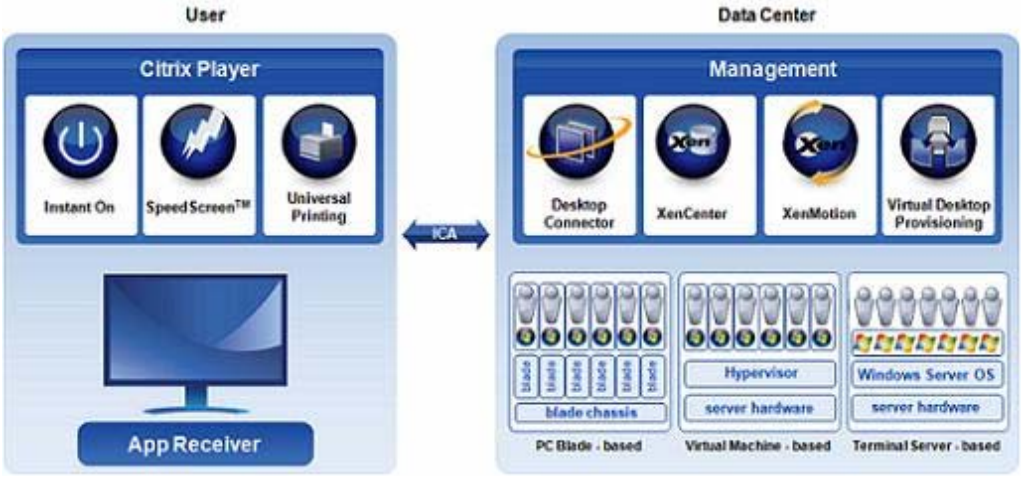
- *EasyCall*. At the 2007 iForum user conference, Citrix unveiled a click-to-call feature, known as EasyCall, which the company will offer as standard for the Platinum Edition of Presentation Server. The Click-to-Call application is connected to the Citrix Application Gateway through Citrix Smart Agent technology. Once the user clicks on a telephone number, Citrix Smart Agent captures and transmits the telephone number to the Application Gateway. The Application Gateway uses LDAP integration to match the user with the appropriate telephone extension. The Application Gateway then takes control of the user's telephone using the CTI (computer telephony interface) into the call server, places the telephone in an off-hook mode, and automatically dials the number passed from the Citrix Telephony Agent. Alternatively, the Application Gateway can broadcast a dial rule to the telephone with the selected number to the user's IP telephone. By integrating EasyCall functionality into XenDesktop, Citrix would enable seamless telephony to users of virtual desktops.

Broad Product Portfolio Addresses Multiple User Types

Citrix Systems' installed base of more than 160,000 customers utilize Presentation Server to run applications on a central terminal server and then allow end users desktop access to that server—a solution that addresses upwards of 80% of the total desktop end user community. However, power users (e.g., software developers or financial traders) need more performance, data isolation, desktop personalization, and control (e.g., remote

reboot) than can be provided by a traditional server-based computing solution, such as Presentation Server.[7] We believe that through combining Presentation Server's unmatched application publishing capabilities and ICA protocol with the soon-to-be-released XenDesktop solution that dynamically provisions virtual machines containing unique desktop PC images, Citrix Systems can address an even broader end market—satisfying nearly 100% of all desktop user requirements and deployment scenarios with differing solutions for each scenario's unique requirements. (See Exhibit 33.)

Exhibit 33: XenDesktop Architecture For Multiple User Type Scenarios

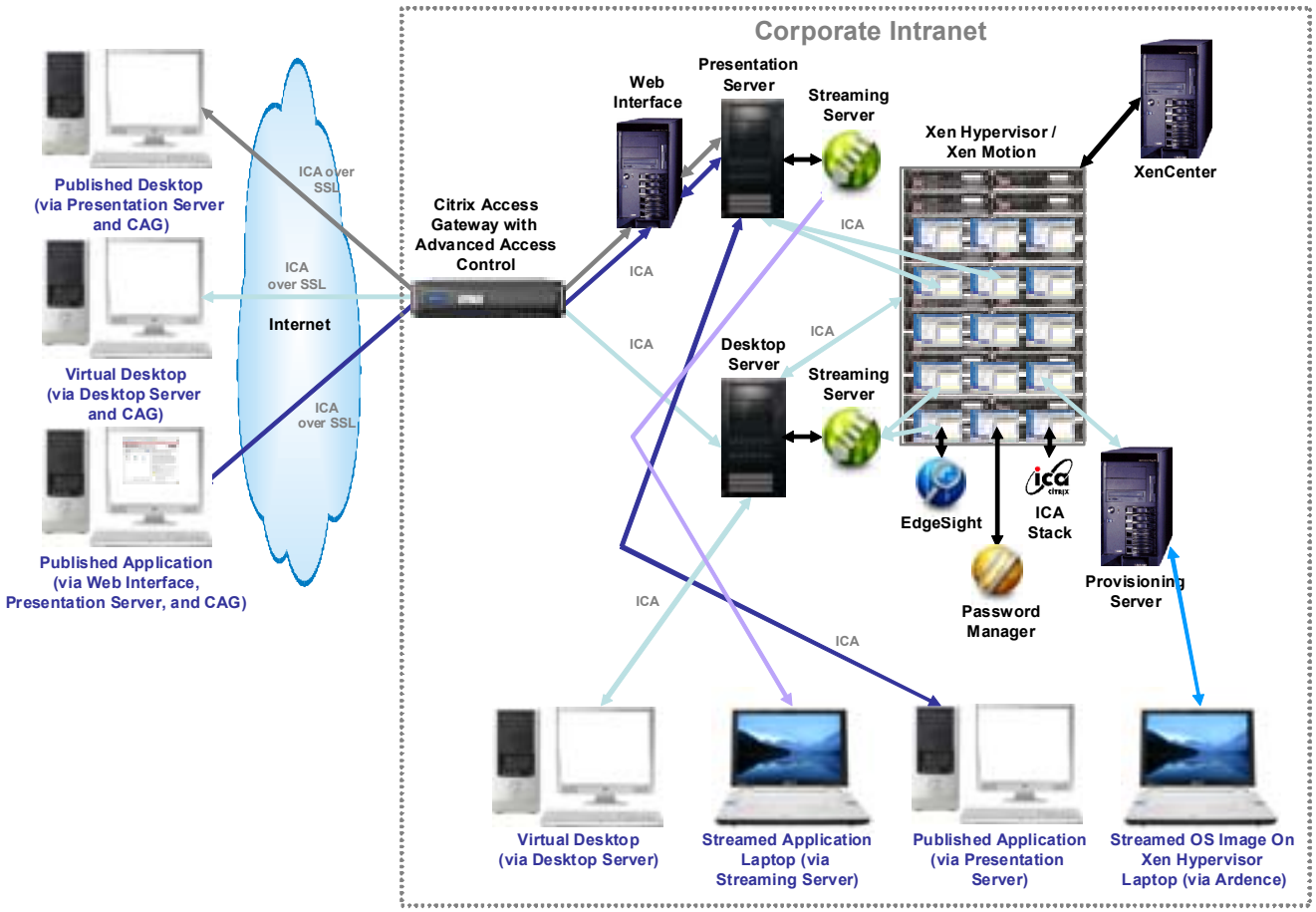


Source: Citrix Systems

The XenDesktop's desktop connector functionality provides an integrated method to connect end users to different types of data-center provided computing power. For example, virtual desktops provide full user personalization while offering the security and reliability of a centrally-managed desktop; Terminal Server-based desktops offer the greatest possible scalability with extremely high reliability to users performing repeatable/predictable tasks; and blade based systems can serve the needs of CAD designers or other users who have very high performance requirements for their computing environment.[15]

XenDesktop provides a mechanism to manage connections to Windows desktop images on virtual machines or PC blades or Presentation Server,[48] and Citrix Systems' broad product portfolio can provide multiple access scenarios based on the end users' specific requirements. For example, a secretary might only need a published desktop through Presentation Server; a trader might need connection brokering to a specific blade PC; an outsourced software programmer might require a virtual desktop to be delivered through XenDesktop via the Citrix Access Gateway; if a "road warrior" needs to access applications offline, application streaming technology can stream those applications onto his/her corporate laptop for disconnected use or an offline Ardence solution could stream the entire operating system image into a Xen virtual machine installed on his/her corporate laptop; and/or a partner might need access to a specific application that could be published to Presentation Server and presented to the user through Web Interface. (See Exhibit 34.)

Exhibit 34: Citrix System's Product Portfolio For Multiple User Types And Desktop Delivery Scenarios



Source: Credit Suisse

The processes involved in creating a Virtual Desktop Utility and a holistic desktop delivery infrastructure that we just described are undoubtedly complex. However, Citrix Systems actually has experience managing many of these issues in the Presentation Server world.[16] While XenSource's virtual infrastructure management tools are more immature versus more-established vendors, such as VMware, if Citrix can develop robust management virtual infrastructure management software and effectively meld its diverse product portfolio into a seamless desktop delivery infrastructure solution through increased R&D and effectively market XenDesktop through its channel, its sales force, we believe that Citrix can establish itself as a strong competitor in both desktop and server virtualization in the next two to three years—positioning the company to capture much of the incremental growth detailed in Exhibit 19.

Protocols Matter – ICA Versus RDP

In our opinion, one of the primary issues with several desktop virtualization solutions is the inherent limitations of Microsoft's Remote Desktop Protocol (RDP). When a user connects over RDP from India to London, for example, to a London Windows desktop image, latency is introduced—something near 500 milliseconds—and performance degrades significantly. In comparison, Citrix's Independent Computing Architecture (ICA) protocol offers more robust performance than RDP over latent networks and, therefore, is more useful for branch office, remote access, and outsourcing deployments. Additionally, ICA provides stronger graphical performance and multi-monitor support than RDP.[16] Citrix administrators, with whom we have spoken, believe that decoupling ICA and having the ICA stack reside on the Windows image represents the most appropriate solution to the

latency problem inherent to RDP. In our opinion, enabling the key differentiating features of ICA versus RDP, such as SpeedScreen, Session Reliability, virtual channel control, etc., provides Citrix Systems with a competitive advantage in the virtual desktop market—especially in large, multinational organizations with distributed users and with users seeking remote access to virtualized desktops.

VMware

VMware's products are used for server consolidation and containment, disaster recovery and business continuity, capacity planning and development, enterprise desktop hosting, test optimization, and software distribution. The products fall into three categories: virtualization platforms, virtual infrastructure automation, and virtual infrastructure management. The products range from consumer desktop solutions to enterprise data center solutions.

Although the company doesn't break out revenue by product type, VMware's VI3 (Virtual Infrastructure 3) suite, which is based on the ESX platform, generates the vast majority of revenue. The main driver for these sales is server consolidation. VMware has had three releases of ESX since its introduction in 2001. ESX1, launched in 2001, included hypervisor-based virtualization. ESX 2, launched in 2003, added management, capacity planning and physical-to -virtual migration features. VMware Virtual Infrastructure 3, introduced in June 2006, added more management capabilities and disaster recovery features through VMware HA, distributed resource scheduler, and consolidated backup.

VMware Infrastructure 3 also included three bundles, the Starter, Standard, and Enterprise editions. The list price per 2 processors is $1,000, $3,750, and $5,750 for the Starter, Standard, and Enterprise editions, respectively. Although pieces of the product can still be purchased, most customers purchase one of the suites.

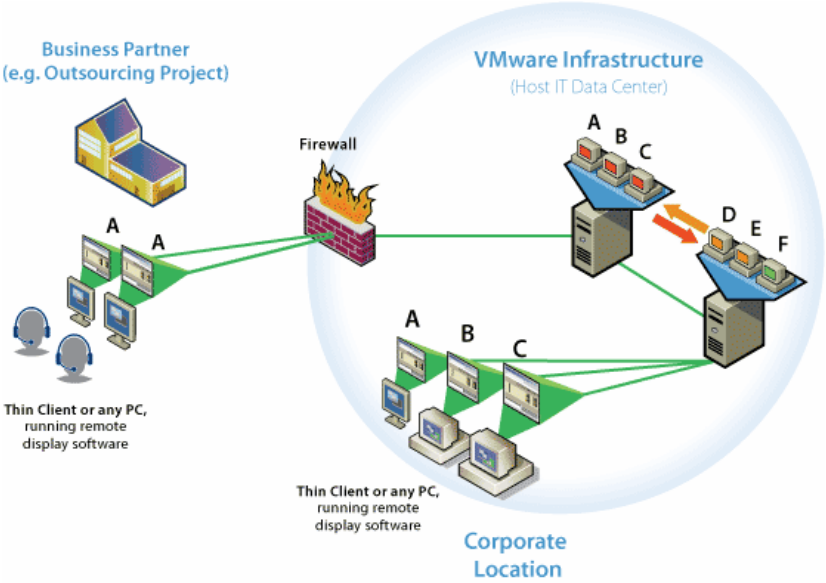
VMware's two streams of license revenue are divided into virtualization platform products and virtual infrastructure automation and management products. Over the past few years, the automation and management business has grown more rapidly than the virtualization platform products line of business. We believe the higher growth rate of the virtual infrastructure and management business implies that more customers are selecting the Enterprise edition bundles. VMware's pricing effectively has increased ASPs as more customers purchase higher-end solutions that include management capabilities. The Enterprise edition's high value features include VMotion, high availability, distributed resource scheduler, and consolidated backup features.

Virtual Desktop Infrastructure (VDI)

In a traditional enterprise environment, dedicated desktop resources increase based on the number of users, and desktop resource utilization rates are very low. IDC estimates that average desktop resource utilization is below 5%. Also, IT labor costs have typically been very high because of high demand for maintenance, upgrades, and capacity additions. The TCO for a single distributed desktop includes hardware, maintenance, help desk support, change management (application provision and patching), and unplanned downtime; as a result, TCO can be very high. Desktop virtualization again enables resources to be shared efficiently, especially in development and test environments. Many users can share resources rather than needing a specific configuration for each desktop machine.

With VMware's Virtual Desktop Infrastructure solution, IT departments can add a higher degree of security and control while spending less time managing the desktops for offsite and outsourced business operations. The IT organization hosts a complete desktop environment for each offsite user—operating system, applications and configurations—in virtual machines, running in the company's secure data center.[26]

Exhibit 35: VMware Virtual Desktop Infrastructure



Source: VMware

VMware Virtual Desktop Infrastructure enables organizations to host desktops inside virtual machines running on centralized servers and provides benefits of server-based computing without limitations of shared services technologies or application integration hassles. Users can access their virtual desktops using a remote display protocol. VDI enables organizations to:

- Manage desktops centrally, simplifying desktop installations, backups, and maintenance.
- Control access to sensitive data and intellectual property by maintaining information in a secure data center.
- Provide individual isolated virtual desktops to end users that look and feel like their normal desktop.

VDI leverages VMware's Virtual Infrastructure 3 (VI3) so a virtual desktop can be customized to run any operating system by optimizing the resources associated with the virtual machine that runs it. For example, companies migrating to Vista need not upgrade their physical PCs but instead can tune the virtual machines by allocating more CPU and memory resources. An end user experience in the virtual desktop can be customized based on specific needs regardless of the physical PC or thin-client used to access a virtual desktop.[26]

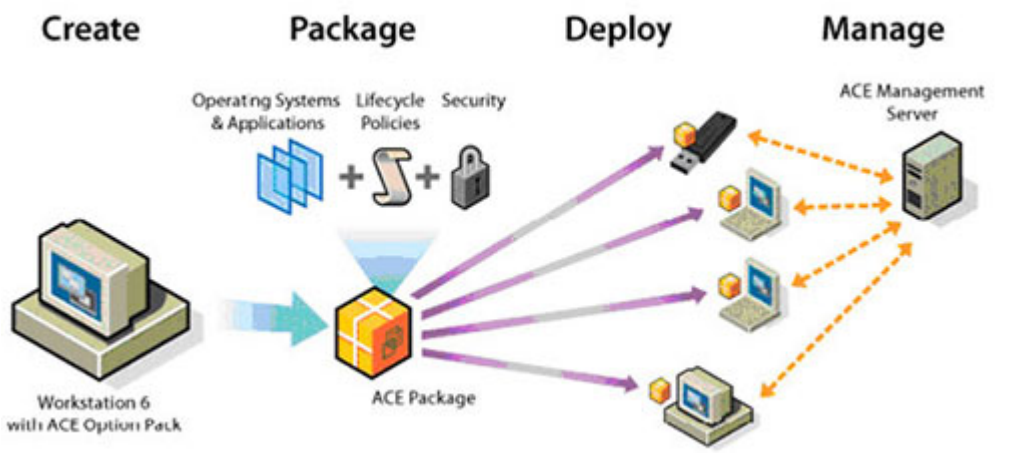
VMware ACE

VMware ACE 2 is an enterprise solution that organizations use to provision standardized client PC environments inside centrally-managed virtual machines called ACEs. Each ACE contains a complete client PC—including the operating system and all applications. Desktop administrators use the policy configuration capabilities in ACE to lock down endpoints with device and network access control, thereby protecting confidential data and enabling compliance with IT polices.[26]

VMware ACE addresses the tasks of deploying, maintaining, and controlling desktop environments—from managed company-owned PCs to employee-owned and third-party PCs. With ACE, administrators can design once and deploy PC environments to desktops, laptops, and portable media devices. ACE lets administrators configure, control, and

establish security parameters for a virtual machine and once deployed, ACE clients can be tracked, modified, and deactivated at any time via the ACE Management Server.[26]

Exhibit 36: VMware ACE



Source: VMware

With VMware ACE 2, IT administrators use VMware Workstation 6 to create and package a hardware-independent, IT-managed PC within a secured virtual machine and deploy it to a properly licensed physical PC or portable media device such as a USB flash drive. VMware ACE Management Server delivers control and management of virtual desktop image from a centralized console and supports dynamic policy updates, including the ability to activate or deactivate a virtual desktop at any time.[26]

With Workstation 6, ACE authoring capabilities are enabled through the ACE Option Pack so that a single platform can be used by an administrator to not only test and develop applications with virtual machines, but also create and deploy controlled ACE packages to end users. The addition of the VMware ACE 2 Management Server provide the capability to track and dynamically activate or deactivate and update policies for ACE clients.[26]

Microsoft

As the future importance of virtualization technologies to the enterprise became clear, Microsoft eventually entered the virtualization space on February 18 by acquiring Connectix, which provided the technology for Microsoft's PC Express/Virtual PC and Virtual Server product lines. Connectix's primary product, known as Virtual PC, provided Microsoft with emulation software for desktop computers, while the (at the time) unreleased product called "Virtual Server" offered Microsoft an entry into server-based virtualization market.[51]

Both PC Express/Virtual PC and Virtual Server are based on a host architecture where Microsoft's standard Windows products are used as the host to integrate with its management tools. This host architecture adds more overhead than paravirtualization architectures. However, Microsoft does intend to offer a hypervisor for the next version of Windows Server 2008.

From a virtual desktop infrastructure standpoint, Microsoft has not articulated a strategy to target this market, and in fact, Mike Neil, Microsoft General Manager for Virtualization Strategy, stated in an interview with SearchServerVirtualization.com, "I'm somewhat surprised at how quickly companies are investing in these technologies," and in the interview, Neil went on to say that "Terminal Server via our partnership with Citrix is behind most of the centralized desktop deployments today."[26] To date, Microsoft's most significant acknowledgement of the desktop virtualization was the announcement in April 2007 that Microsoft will enable new ways to deploy Windows Vista, including new options to license

desktop virtualization and diskless PCs. Specifically, Microsoft announced a change in licensing for customers using Windows Vista Enterprise with Software Assurance—adding two new ways to license and deploy the operating system: 1) the license right to use Windows Vista on diskless PCs and 2) the availability of a subscription license called Windows Vista Enterprise Centralized Desktops (VECD). Essentially, the diskless PC and centralized virtual machine licensing changes enable enterprises to deploy OS streaming or virtual desktop technologies, respectively, while still maintaining compliance with Microsoft license agreements

Additionally, Microsoft has begun to view desktop virtualization as a means to drive adoption of Windows Vista. Mike Neil, Microsoft General Manager for Virtualization Strategy, stated in an interview with SearchServerVirtualization.com, "The new [virtual desktop] scenario, I think, is going to help us. If you're going to go about deploying an architecture that is significantly different than what you've done in the past, you might as well be trying Vista as part of that solution. It's sensible to migrate to something you probably were going to use anyway." Obviously, Terminal Server is widely used today for centralizing applications in the data center and remotely presenting and accessing them, and Microsoft has added functionality to Windows Server 2008 to enhance Terminal Services capabilities, such as access from outside the firewall. In addition to desktop virtualization, Microsoft's acquired SoftGrid technology represents another component making the migration to Windows Vista more viable by allowing for application isolation, which resolves many application compatibility and interaction problems. Being able to stream applications onto those virtual machine desktop images enables another layer of abstraction and increased flexibility. Ultimately, Microsoft's Neil summed up the desktop virtualization opportunity, combined with Windows Vista and SoftGrid, saying, "The combination of moving to Vista and then SoftGrid for application deployment makes a lot of sense if you're going to be making a radical change in the way you architect your client systems, moving them into a centralized environment."[26]

While the company has not articulated a virtual desktop infrastructure strategy, among the first steps that Microsoft would need to take to develop a virtual desktop infrastructure would be the creation or acquisition of a connection broker. A connection broker validates the user name and provides a connection for that user; provides the ability for the user to access multiple VM pools; monitors the activity level of a given virtual machine and sets status to active or inactive; and handles reassignment of a virtual machine when a user disconnects.

Ultimately, Microsoft has the resources—including several existing virtualization technologies (e.g., Softricity, Terminal Services, Hyper-V, and Virtual PC) and associated profile management and configuration software tools (e.g., Active Directory and Microsoft System Center)—and the customer base to create some significant competition for other players in the desktop virtualization space.

Windows Server 2008 Hyper-V

Microsoft's Windows server hypervisor technology, code-named Viridian or, more recently, Hyper-V, will run beneath the operating system and manage resources for multiple VMs. Microsoft states that even though Hyper-V will not be immediately available when Windows Server 2008 ships, Windows Server 2008 will be "virtualization ready." However, several features in the initial version of Microsoft's Hyper-V hypervisor software have been eliminated in order to ship the new virtualization technology on time.

To maintain the release schedule, Microsoft is changing three primary features but will include them in a future release to be named Windows Server Virtualization. One of the primary features to be eliminated would allow people to move a virtual machine from one physical server to another. Without this feature, Microsoft Hyper-V will not be appropriate for sophisticated virtual computing environments, although Hyper-V still could be used in smaller data centers. Also eliminated from the first release is support for machines that have more than 16 processing cores, along with support for memory, network cards, and

processors that are added “on-the-fly.” The release schedule mandates that Hyper-V be released within 180 days of completion Windows Server 2008.

Microsoft has acknowledged that VMware’s free server product, along with Red Hat and Novell SUSE providing virtualization technology in their server products, has resulted in requests from its customer base to make its hypervisor software free. Microsoft’s current plan is to license the Datacenter Edition of Windows Server 2008 but also to provide users the right to run an unlimited number of virtual instances on one physical server. The Enterprise Edition of Windows Server 2008 is expected to allow four virtual instances per license.

In addition to its relationship with XenSource, Microsoft also announced an alliance with Novell in November 2006. While the technical depth of this alliance is difficult to assess, Novell and Microsoft will work together to deliver Xen-enabled versions of Windows for SUSE Linux and Hyper-V-enabled versions of SUSE Linux for Windows. We believe both the XenSource and Novell relationships will benefit Microsoft and give it more market power to commoditize the hypervisor layer of virtualization.

Terminal Services

Terminal Services is a component of Microsoft Windows (both server and client versions) that allows a user to access applications and data stored on a remote computer over a network. In addition to the server-based components of Terminal Services, Microsoft provides the client software Remote Desktop Connection, available for most 32-bit versions of their Windows operating systems including Windows Mobile and Apple’s Mac OS X, which allows a user to connect to a server running Terminal Services.[51] The origin of Terminal Services streams from an agreement on May 12, 1997 reached by Microsoft and Citrix Systems, through which Microsoft would license MultiWin from Citrix and incorporate the source code into future versions of its Windows server operating systems as a features known as Microsoft Terminal Server.[52]

Terminal Services is Microsoft’s implementation of thin-client terminal server computing, where Windows applications, or even the entire desktop of the computer running terminal services, are made accessible from a remote client machine. With Terminal Services, only the user interface of an application is presented at the client system. Any input to it is redirected over the network to the server, which is where all the processing the application requires happens. This is in contrast to application streaming systems, such as Microsoft SoftGrid, in which the applications, while still stored on a centralized server, are streamed to the client on-demand and then processed by the client machine.[51]

For an enterprise, Terminal Services allows the IT departments to install the applications on a central server. For example, instead of deploying database or accounting software on all desktops, the application can simply installed on a server and remote users can log on and use it across a network. As long as the employees have the Remote Desktop software, they will be able to use the application. This centralization makes upgrading, troubleshooting, and software management much easier.[51]

Terminal Services in Windows Server 2008 provides new functionality to connect to remote computers and applications. Terminal Services Remote Programs integrates applications running on a remote terminal with users’ desktops such that they more closely behave as if they were running on an individual user’s local computer—enabling users to run programs from a remote location side-by-side with their local programs. Terminal Services Web Access permits the flexibility of remote application access via Web browser, granting a wider variety of ways users can access and use programs running on remote terminals. Terminal Services Gateway allows users to access remote terminals and remote terminal programs across network address translators and firewalls.

Softricity

In May 2006, Microsoft announced its intent to acquire application streaming and virtualization software vendor Softricity for an undisclosed amount. Softricity Desktop, the

company's flagship product, accelerates the deployment and management of an enterprise's software infrastructure by virtualizing applications, enabling them to be deployed on-demand without installation or altering the computers they run on. Softricity Desktop is made up of two components: 1) SoftGrid Platform, the engine that powers the system, and 2) Softricity ZeroTouch, the front-end that provides worldwide availability to applications.[35]

Softricity's SoftGrid Platform accelerates the deployment and management of an enterprise's software infrastructure by virtualizing applications—enabling them to be deployed on-demand to desktops, laptops, and servers with installation or altering the computer they are on.[35]

At its core, SoftGrid consists of SoftGrid Virtual Application Server and SoftGrid Clients. The server, which can support over 1,000 users, serves the applications, which run on the clients. SoftGrid Clients communicate at login with the SoftGrid Virtual Application Server to receive shortcuts to applications users have the right to access. When an end user launches a SoftGrid-managed application, the SoftGrid Client authenticates with the server, checking authorization and license compliance.[35]

The first time a user launches an application, the SoftGrid Virtual Application Server begins delivering the application's executable code to the client. Only a fraction of the code—often only 20%—needs to be delivered before the application executes, given that during the sequencing process Softricity determines which portions of the application are required for launch. As the user continues using the application, additional code is delivered to the clients as necessary based on the features of the application that are utilized.[35]

Since the application executes on the client, it performs as if installed locally. However, the application is never actually installed on the client. Instead, the application executes within SystemGuard, which is a "virtual sandbox" environment that protects the host operating system from being altered by applications. SystemGuard enables applications to run on any compatible computer without the need for installation and configuration. Within SystemGuard, each application has its own set of configurations so they do not depend on the configuration of the host, a situation completely opposite of traditional software deployment, and because of this, any application can run side-by-side with any other application without conflicts. This reduces the regression testing required for traditional software deployment to determine potential application conflicts, which speeds time-to-deployment and reduces overhead costs. These applications are then cached locally for subsequent use, and therefore, Softricity can even be utilized for laptops.[35]

By integrating application virtualization and on-demand streaming from Softricity into Microsoft SMS, enterprises can accelerate and cut the costs of application deployments. With SoftGrid for SMS, thousands of users would be able to utilize their existing SMS infrastructure to manage, push, or stream virtualized applications to any desktop. Specifically, the IT administrator can use SMS to distribute the icons and then utilize SoftGrid to deploy the virtual applications.[35]

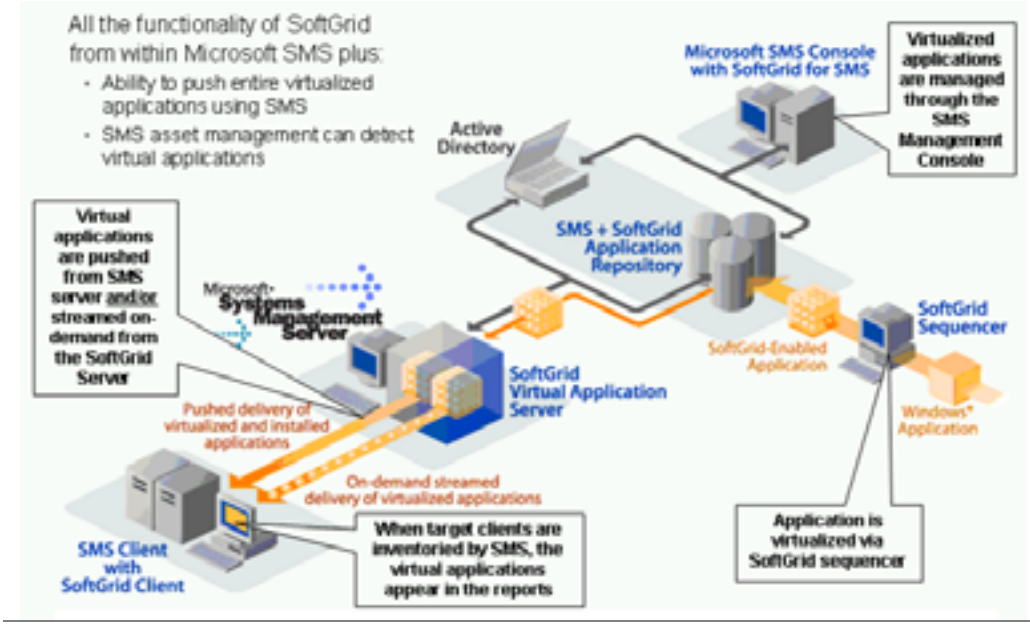
SoftGrid for Microsoft Systems Management Server has been designed to provide a single management interface for both locally installed and virtualized applications. IT now has the option to push entire virtualized applications to client computers using SMS deployment delivery and/or pull them on-demand with Softricity's streaming technology.[35] The key benefits of this joint solution for application deployment are:

- Integration of application virtualization and on-demand streaming into SMS, which enables IT departments to manage and deploy virtualized applications within the SMS management console.[35]
- Acceleration of application deployment via SMS by 1) eliminating configuration conflicts and reducing regression testing (i.e., making sure that new applications will not conflict

with existing applications on a user's desktop), 2) instantly upgrading and repairing applications, and 3) providing on-demand access to apps from any computer.[35]

- Reduction of costs of SMS application deployment and management by 1) shrinking time-consuming application deployment and management process, 2) containing application infections (i.e., if an enterprise deploys the Internet Explorer application in a virtual environment, all unwanted malicious code is contained only in that virtual environment), 3) reducing images (i.e., it is no longer required to install all applications which reduces the size of the application image and/or OS image), and 4) simplifying OS and application migrations (i.e., by moving the bulk of the applications out of the image and having them persist on the network, OS migrations are simplified).[35]

Exhibit 37: SoftGrid for SMS Architecture and Feature Benefits



Source: Softricity

An SMS management console extension of Softricity's solutions would enable the ability to create SMS packages that contain SoftGrid virtual applications, and IT administers could then track the inventory and meter those application on the desktops as they would through traditional SMS asset management discovery and metering systems. Furthermore, dynamic delivery is possible via Softricity's streaming technology to deliver only the necessary portions of the virtualized applications in real-time based on end users requests which reduces LAN/WAN ultilization.[35]

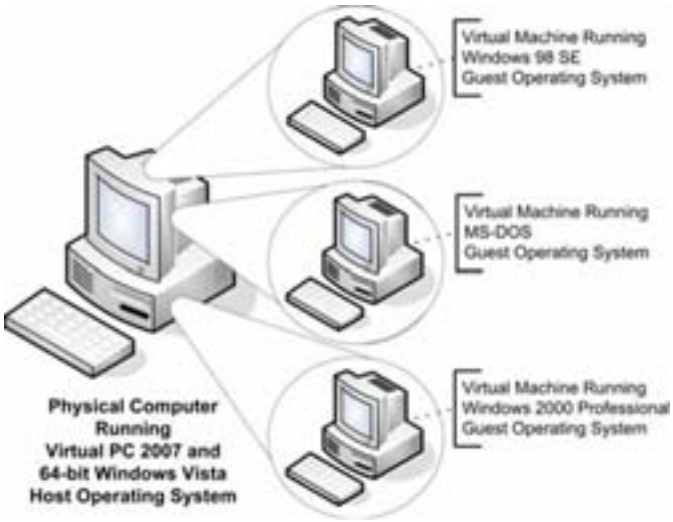
In the long run, we believe that Microsoft could integrate Softricity's technology into the Windows operating system. In our opinion, Microsoft eventually wants to move from massive OS upgrades to making the OS more modular, and Application virtualization could also be used to perform OS component virtualization, allowing Microsoft to update a portion of the OS and still provide compatibility to applications that had dependencies on the old component, given that the virtualized program through SoftGrid would not be installed on the client and, therefore, would not be impacted by the host operating system or other applications.[53]

Microsoft Virtual PC

Microsoft Virtual PC is a virtualization suite for Microsoft Windows operating systems. With Microsoft Virtual PC, IT administrators can create separate virtual machines on Windows desktops, each of which virtualizes the hardware of a complete physical computer. Microsoft Virtual PC can run operating systems such as MS-DOS, Windows, and OS/2. In addition, multiple operating systems can run at once on a single physical computer, and

users can switch between the operating system instances instantly. Microsoft positions Virtual PC as a solution for scenario in which users need to support multiple operating systems for tech support, legacy application support, training, or just for consolidating physical computers.[54]

Exhibit 38: Microsoft Virtual PC 2007



Source: Microsoft

Exhibit 39: Microsoft Virtual PC 2007 Screenshot

Source: Microsoft

The first version of Virtual PC was originally developed by Connectix for the Macintosh and was released in June 1997. Connectix was subsequently acquired by Microsoft. In June 2001, the first version of Virtual PC for Windows, version 4.0, was released. Connectix sold versions of Virtual PC bundled with a variety of operating systems, including many versions of Windows, OS/2, and Red Hat Linux. In July 2006, Microsoft released the Windows-hosted version as a free product. In August 2006, Microsoft announced the Macintosh-hosted version would not be ported to Intel-based Macintoshes—effectively discontinuing the product as PowerPC-based Macintoshes are no longer manufactured.[51]

Quest Software

Quest Software quietly entered the virtualization market with the acquisition of privately held Vizioncore in early 2007, which has since been operating as a separate subsidiary. Founded in 2002, Vizioncore began as a consulting company specializing in the virtualization market working with products from VMware and Citrix Systems. Quest extended its virtualization capabilities with the 2007 acquisition of Invirtus, a provider of optimization, conversion, automation, and management technologies of virtual environments, in order to expand its product portfolio of virtualization infrastructure management solutions. The virtualization management technologies from Invirtus help enterprises maximize their virtualization investment, whether based on Microsoft, VMware, or Virtual Iron platforms.[55]

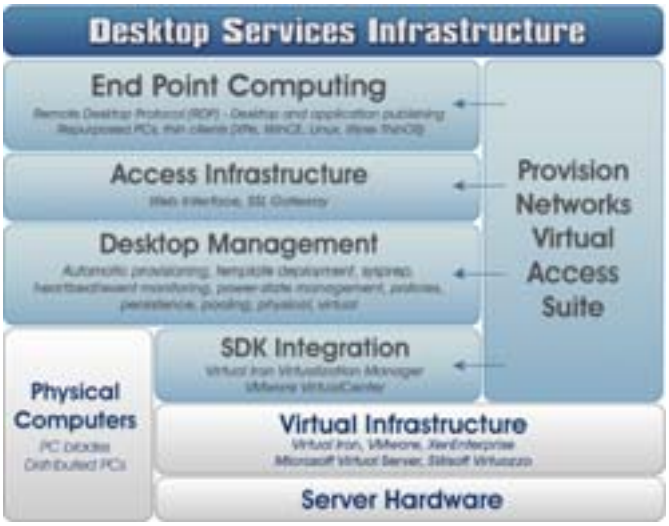
In June 2007, Quest announced the acquisition of privately-held ScriptLogic for approximately $90 million in cash. ScriptLogic is a leading provider of systems lifecycle management solutions for Windows-based networks. The company, founded in 1997, initially made a user desktop configuration management tool for network administrators. Over the years, this basic logon script replacement tool had grown into a complete desktop configuration management solution called the Desktop Authority product. According to ScriptLogic, the virtualization goals of achieving on-demand IT access, creating a secure, consistently functional working environment, and lowering total cost of ownership can only be accomplished by creating a Virtual User Environment. By applying

the configurations that are available through application virtualization to the entire desktop in either an OS virtualization or terminal environment scenario, IT administrators can create the Virtual User Environment.[56]

In April, ScriptLogic released Desktop Authority 7.6, a desktop configuration management solution, with enhancements allowing IT administrators to apply end user-specific settings to desktops regardless if the desktops are running in a physical or virtual environment. With one centralized, consistent policy across all desktops and physical/virtual systems, management costs are lower, migrations are faster, and users can freely move between workstations without consideration for the underlying operating environment.[56] Desktop Authority provides comprehensive coverage of the desktop lifecycle with a specific focus on the area of desktop and user configuration. While virtualization, regardless of the specific implementation, provides an operating system and application workspace for the user, it lacks the management ability to cater the desktop to meet the business needs of the user beyond that of just having the basic applications available.[57]

In November 2007, Quest Software entered the virtual desktop infrastructure market with the acquisition of Provision Networks, a privately held provider of presentation and desktop virtualization solutions. Provision Networks Virtual Access Suite (VAS) is a framework that leverages the VMware Virtual Infrastructure to transform the physical desktop computer and its applications into on-demand virtual services. VAS empowers a hosted desktop infrastructure with VM management and monitoring capabilities, as well as a complete enterprise access and application delivery solution.[58] Virtual Iron and Provision Networks offered a bundled server-hosted virtual desktop solution consisting of the virtual infrastructure provided by Virtual Iron, an access broker to monitor and manage the virtual desktops, and end point terminals to provide on demand access to the virtual desktops.[59]

Exhibit 40: Provision Networks Virtual Access Suite (VAS)



Source: Provision Networks

Provision's business model had been to ally with all the major virtualization vendors, in particular VMware, but also Microsoft, SWsoft, and XenSource. Provision offers a connection broker to ship with VMware's VirtualCenter but also delivers solutions to integrate VMware's products to enable provisioning, cloning, application publishing, access control policies, and full application virtualization.

Hardware

At first glance the terms "thin-client" and "virtual desktop" conjure a negative reaction when referencing traditional desktop PC vendors. After all, the statement that arises is "Technologies that promise to effectively eliminate the physical desktop cannot have

positive implications for those vendors selling desktop PCs. Can they?" Realistically, we believe the trend to virtualize the desktop represents a potential positive for the industry rather than a negative—driving a shift in spending rather than an elimination in spending.

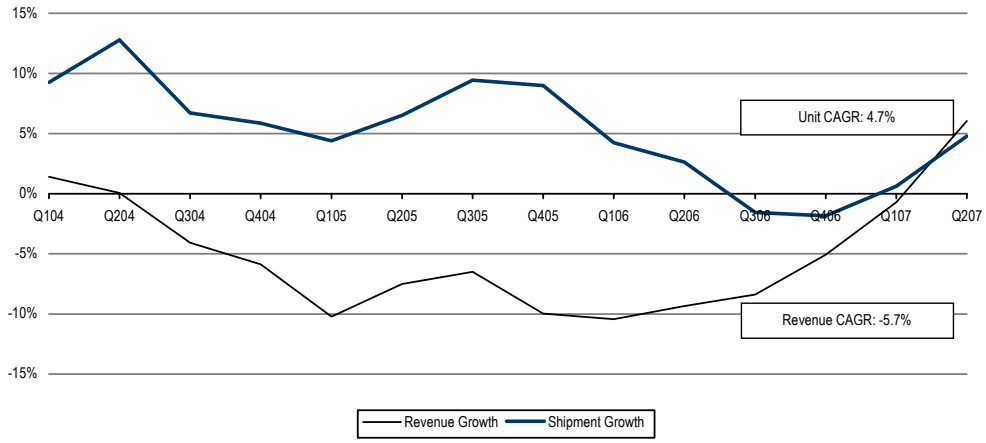
Much like the server OEMs are experiencing with virtualization, the trend to virtualize the desktop shifts spending from the traditional desktop PC to the midrange server, a product which traditionally generates gross margins of 30-50%, compared to the lowly desktop which gleans 15% gross margin on a good day. As we have indicated throughout this report, we estimate that 25-30 virtual desktops can operate on an 8-way HP C-Class blade with 32 GB of memory at a cost of $733-800 per virtual desktop user. This number compares to the average price of today's corporate desktop of $738 according to Gartner, implying little to no hardware price erosion. In essence, the up front price per user is not materially different from a PC/server OEM point of view. Rather, the cost savings are generated over the life of a PC. For example, Gartner pegs the annual TCO over a 5-year life of a corporate desktop PC at $5,000, while we estimate the same virtualized solution could be as low as $2,500. The savings come primarily in maintenance costs, including power, data center footprint, and labor. Interestingly, the purchasing decision will look and feel relatively similar, as most corporate PCs are purchased today in conjunction with server sales in order to streamline purchasing power.

For published desktops, the implications are much more negative for PC/server OEMs. We estimate that 50-60 published desktops can be run on a 4-way IBM LS220 blade with 4-8 GB of memory at a cost of $100-120 per user. It is difficult to ascertain what percentage of corporate desktops today fall into the category but it includes workers who do repetitive tasks including call-center staff, clerical works, retail centers, and branch staff in businesses like banks. Therefore, the potential end user category is certainly meaningful in size.

Industry Units

We believe virtual PCs will have only a small impact over the next 3-4 years on total industry shipments, however, if we are correct and the installed base reaches 25.6 million units by 2011, this would contribute to slower overall corporate desktop unit and revenue growth. Interestingly, things in the corporate desktop market have not been great to begin with as the market has been languishing for several years now, with compound unit growth of only 4.7% over the past three years. Meanwhile, revenue looks even worse, declining 5.7%, demonstrating the deflationary nature of the product category. (See Exhibit 41.)

Exhibit 41: Worldwide Corporate Desktop: Unit and Revenue Growth (Y/Y)

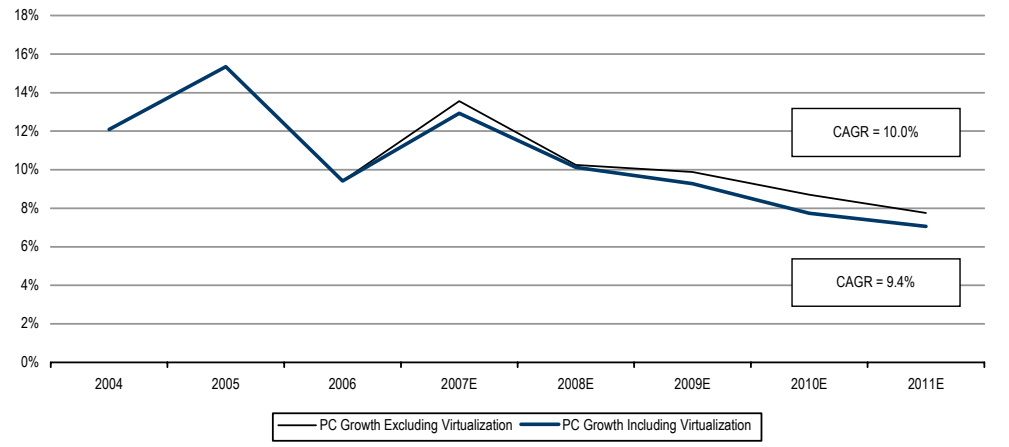


Source: Credit Suisse estimates

Looking forward, we believe the long term growth of the worldwide PC market is 10.0% on a unit basis and 4-5% on revenue basis after factoring in ASP declines of approximately 4-

6% on an annual basis. If the trend towards virtualized desktop PCs takes the current trajectory that we project and reaches an installed base of 25.6 million units in 2011, we estimate this forecast would negatively impact long-term unit growth in the PC industry by about 60 basis points—driving our estimated growth rate from 10.0% to 9.4%. (See Exhibit 42.)

Exhibit 42: Impact of Desktop Virtualization: Worldwide PC Unit Growth in Both Scenarios



Source: Credit Suisse estimates

Conversely, the PC's loss is the server's gain, and while it is difficult to quantify the potential impact on the server market, if we use the base assumption of a 25.6 million unit installed base in 2011, and the midpoint of the $733-800 per user range of virtualized desktops, then there will be a $19.6 billion shift in spending from PCs to servers over a 5 year period. More importantly, the gross margin contribution from $19.6 billion in PCs sales is $2.9 billion (assuming 15% desktop gross margin), while the same level of spending in server sales yields a gross margin contribution of $5.7-9.8 billion, a 2-3.5x multiple of the desktop PC contribution. For this reason alone, we believe the trend towards virtualized desktop PCs is not a negative, but rather, a large positive for the PC & server industry. This is especially true because PC and server companies' stocks are not viewed as growth vehicles, and have historically outperformed during periods of margin expansion more than revenue growth.

Competitive Analysis

The more interesting implications of virtualized desktop PCs are their potential impact on the competitive landscape. To date, the corporate desktop PC market has been dominated by two players—HP and Dell. Both companies have helped to successfully commoditize the desktop PC and drive attractive annual price reductions in the product. However, in an environment where the desktop is virtualized and the hardware device is in fact a midrange server, the competitive dynamics change immediately. To begin with, it is no longer a two horse race as the midrange server market is the traditional domain of not only HP but also IBM and Sun Microsystems. Perhaps more importantly, Dell's presence in the midrange server market is essentially non-existent at this stage.

We believe the shift to virtualized desktops could have significant disruption on PC and server industry market share. For example, IBM's move to exit the PC business in 2004 looks to be prophetic—having sold the business for $1.75 billion with a new opportunity to get right back into the game (at a higher margin) with its bladed solutions. HP, in our opinion, stands to gain the most in this environment as the world's largest vendor of both PCs and servers. HP's C-Class blades are an optimal solution for virtualized desktop environments and HP's presence as the largest vendor of both solutions should help it to set the pace of adoption and help to play the trend towards virtualization on its own terms.

Dell may have the most business at risk given its limited capabilities in the midrange server market. With 40.6% share of the US corporate desktop market and 17.6% share of the worldwide corporate desktop market, the onus on Dell to expand its presence up the stack is becoming increasingly important. Interestingly, while Dell has been mostly silent in 2007 with regard to its strategic direction, the company is quietly becoming more focused on traditional IP heavy areas, notably storage, where it recently purchased EqualLogic, a provider of virtualized storage solutions to small and medium businesses. Obviously, the value proposition of virtualization technologies is not lost on Dell, and we expect the company to invest heavily in this area going forward. What may save Dell is the actual adoption of virtualized desktop solutions will likely be a gradual process which could provide Dell time to build out its midrange server lineup. From a numbers perspective, we estimate the installed base of virtual desktops will be 25.6 million in 2011, implying 8 million units sold in 2011, or about 7.4% of that year's worldwide desktop shipments. As a result, we expect the trend to virtualize on the desktop to be only minimally disruptive to Dell in the near term but Dell must improve its value proposition in the midrange to ensure longer term success.

The wildcard in this scenario is Sun Microsystems, which remains in the workstation market today but has largely avoided commoditized PCs in the last two decades. With a growing presence in the x64 market with its Galaxy servers and the ramping of its Intel business over the next 18 months, not to mention partnerships with Microsoft, Sun is potentially a viable player in virtualized desktops.

Hewlett-Packard

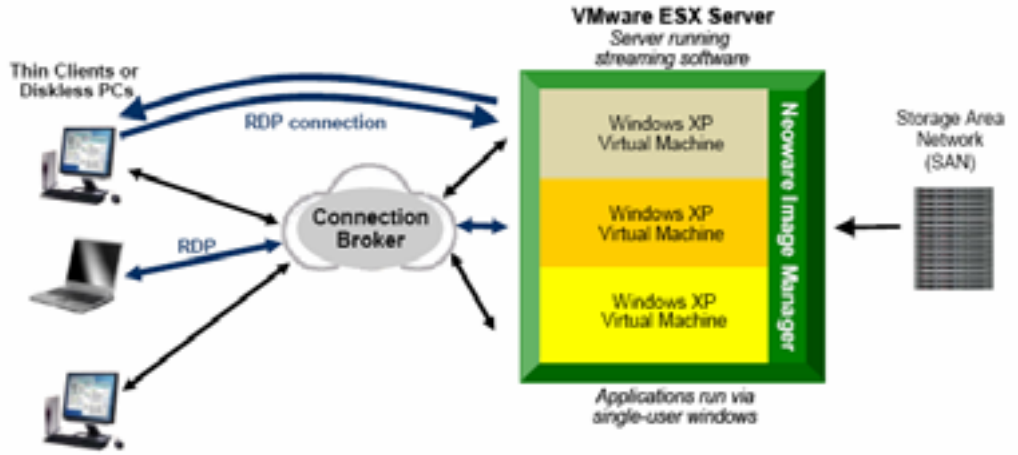
In our opinion, HP stands to gain the most of the PC and server OEMs in a virtualized desktop environment. As the world's largest vendor of both PCs and servers, HP will experience a meaningful rise in profitability as the mix shifts from PCs to servers, if the company can maintain or gain share during this transition. For example, HP receives 35% of its revenue from PCs, which only have 5-6% operating margins, meanwhile, revenue from HP's server and storage business is 18% of total, but carries an operating margin of 10% (a number that has an upward bias to it while the PC profits are closer to peak). Ironically, HP's least profitable PC for the past decade has been its corporate desktop, and as a result, any potential mix shift away from this product is largely positive.

Exhibit 43: Neoware Thin-client Product Line

Source: Hewlett-Packard

HP has been in the process of building out the hardware industry's most complete virtual desktop solution for several years. In July of this year, HP spent a combined $1.84 billion to purchase both Opsware and Neoware. Opsware's management software is critical in virtualized environments, while Neoware augmented HP's existing strength in thin client Windows environments by adding capabilities in Linux. (See Exhibit 44.) Meanwhile, HP's C-Class blades are an optimal solution for virtualized desktop environments on the server side. Notably, HP's presence as the largest vendor of both solutions should help the company set the pace of adoption for the industry and affect the transition on its own terms.

Exhibit 44: Network Architecture With Virtual Clients And Image Streaming Software



Source: IDC

Sources and References

1. IBM Global Financial Markets—“A Total Economic Assessment (TEA) of the Impact of Server-based Computing (SBC)”

2. Gartner—“Evaluate if Server-Based Computing Is Right for You”

3. www.thinclient.net—“Overview of Thin-client/Server-based Computing”

4. Hewlett Packard—“HP Remote Workstation Software”

5. IDC—“Worldwide Virtual Client Computing 2007-2011 Forecast”

6. VMware—“Addressing Desktop Challenges with a VMware Virtual Desktop Infrastructure”

7. www.leostream.com

8. HP—“HP Virtual Desktop Infrastructure Podcast Script”

9. www.thinclient.net—“Overview of Thin-client/Server-based Computing”

10. www.emergic.org—“Server-based Computing: A Brief History of Computing (Part 2)”

11. IBM Global Financial Markets—“A Total Economic Assessment (TEA) of the Impact of Server-based Computing (SBC)”

12. Forrester Research—“Best Practices: IT growth and Innovation”

13. Gartner—“When Thin-clients Can Narrow Your TCO”

14. VMware—“Addressing Desktop Changes with a VMware Virtual Desktop Infrastructure”

15. www.citixsystems.com

16. brianmadden.com—“Providing Windows Applications to Users: Nine Different Theories and Architectures”

17. www.microsoft.com

18. ComputerWorld—“Microsoft adjusts to add support for thin-client computing”

19. IDC—“Worldwide Software Distribution 2005-2009 Forecast and 2004 Vendor Shares”

20. www.samachar.com—“Server-based Computing Redux”

21. www.brianmadden.com

22. Citrix Systems—“Maximizing the Value of Your Citrix Investment—Why Upgrade to Citrix Presentation Server 4.0”

23. www.hp.com

24. IBM Global Financial Markets—“A Total Economic Assessment (TEA) of the Impact of Server-based Computing (SBC)”

25. Hewlett Packard—“HP Remote Workstation Software”

26. www.vmware.com

27. Ron Ogelsby—“Virtual Desktop Infrastructures (VDI): What's real today, what's not, and what's needed”

28. www.virtualization.info—“Virtualization lacks of management tools”

29. Server Pipeline—“Blade Management Tools Take Center Stage”

30. IDC—“Worldwide Virtual Client Computing 2007–2011 Forecast: The Virtualization Revolution: Rethinking Client Computing”

31. VMware—“VMware ACE”

32. Gartner—“Desktop Management Tool Market Driven by TCO Concerns”

33. Citrix Systems—“Marico Boosts Availability of SAP Applications with Centralized Management”

34. SD Times—“Seeing the Logic of Centralized Application Management”

35. www.softricity.com

36. MS Terminal Services—“The benefits of Application Streaming in a TS/Citrix environment”

37. InfoWorld—“SoftGrid opens a stream toward application manageability”

38. Microsoft—“Flexible Desktop Computing”

39. Gartner—“Application Streaming Will Not Make Server-Based Computing Obsolete”

40. Doug Brown—“To Install or Not Install”

41. Ardence—“Nothing “Thin” About Ardence Software. Streaming Capabilities Are Changing the Cost And Management Structure for Desktops”

42. VMware—“VDI: A New Desktop Strategy”

43. brianmadden.com—“Disk image management in VDI environments: VMware, Ardence, shared disks, and the offline goal”

44. webwereld—“VM Managers Make a Virtual Two-horse Race”

45. www.kidaro.com

46. Citrix Systems—“Server-Side Application Virtualization”

47. Citrix Systems—“Accelerate mySAP ERP Deployments”

48. Ron Ogelsby—“Citrix plans to enter VDI space: An analysis of their solution”

49. www.thethin.net

50. www.virtualization.info—“Virtualization lacks of management tools”

51. www.wikipedia.com

52. USA Today—“Citrix Microsoft Crisis 1997”

53. www.thin.net

54. www.microsoft.com

55. www.invirtus.com

56. www.quest.com

57. ScriptLogic—“Virtualizing the Desktop with ScriptLogic Desktop Authority”

58. www.provisionnetworks.com

59. Virtual Iron—“Server-Hosted Virtual Desktop Infrastructure”

Companies Mentioned *(Price as of 20 Nov 07)*
Apple Inc. (AAPL, $168.85, OUTPERFORM, TP $210.00, MARKET WEIGHT)
Citrix Systems Inc. (CTXS, $37.20, OUTPERFORM [V], TP $45.00, OVERWEIGHT)
Dell, Inc. (DELL, $26.31, OUTPERFORM, TP $35.00, MARKET WEIGHT)
Hewlett-Packard (HPQ, $49.56, OUTPERFORM, TP $60.00, MARKET WEIGHT)
International Business Machines (IBM, $103.42, NEUTRAL, TP $115.00, MARKET WEIGHT)
Microsoft Corp. (MSFT, $34.58, OUTPERFORM, TP $40.00, OVERWEIGHT)
Novell (NOVL, $6.36, UNDERPERFORM, TP $7.00, OVERWEIGHT)
Quest Software, Inc. (QSFT, $16.30, NEUTRAL, TP $18.00, OVERWEIGHT)
Red Hat Inc. (RHT, $18.90, NEUTRAL [V], TP $22.00, OVERWEIGHT)
Sun Microsystems Inc. (JAVAD, $19.47, UNDERPERFORM, TP $22.00, MARKET WEIGHT)
Symantec Corporation (SYMC, $17.29, OUTPERFORM, TP $23.50, OVERWEIGHT)
VMware Inc. (VMW, $82.62, NEUTRAL [V], TP $85.00, OVERWEIGHT)

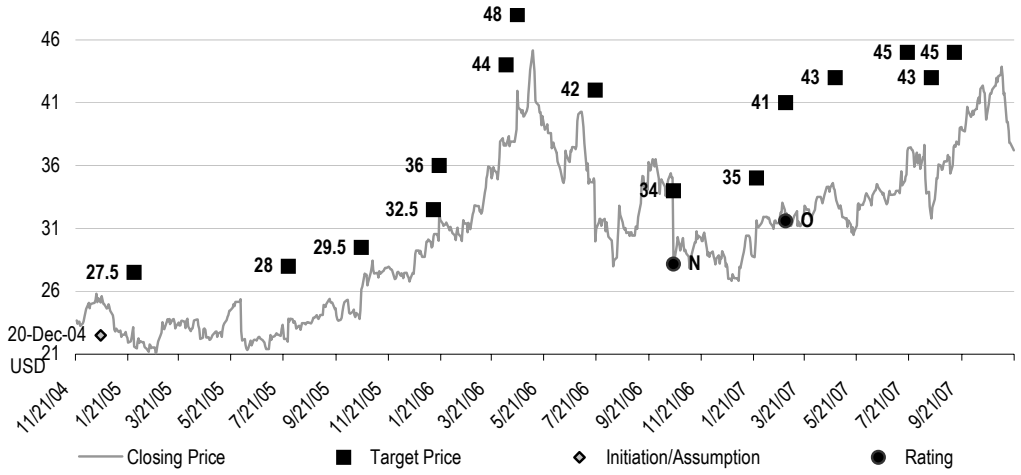
Disclosure Appendix

Important Global Disclosures

I, Philip Winslow, CFA, certify that (1) the views expressed in this report accurately reflect my personal views about all of the subject companies and securities and (2) no part of my compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this report.

See the Companies Mentioned section for full company names.

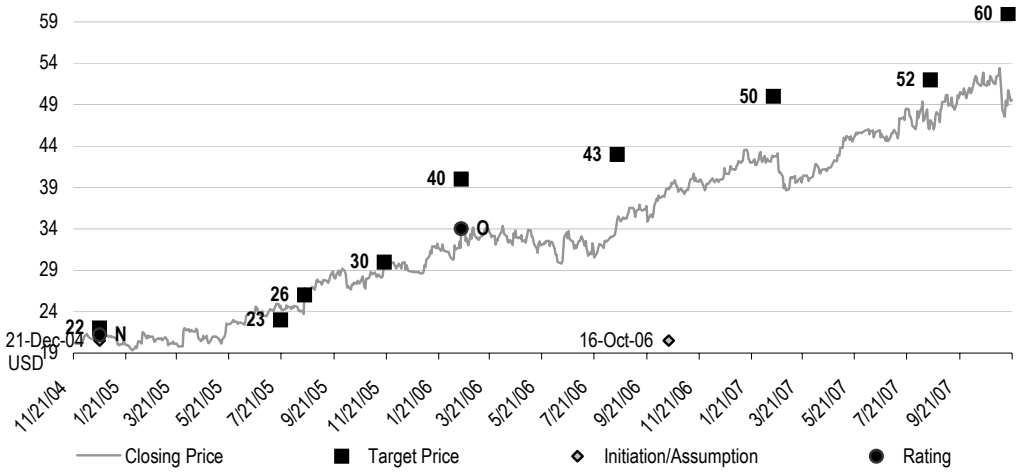
3-Year Price, Target Price and Rating Change History Chart for CTXS



O=Outperform; N=Neutral; U=Underperform; R=Restricted; NR=Not Rated; NC=Not Covered

CTXS Date	Closing Price Price (US$)	Target Price Price (US$)	Rating	Initiation/ Assumption
12/20/04				X
1/28/05	21.6	27.5		
7/27/05	23.83	28		
10/20/05	26.15	29.5		
1/12/06	30.36	32.5		
1/19/06	32.38	36		
4/7/06	37.59	44		
4/20/06	41.95	48		
7/20/06	29.97	42		
10/19/06	28.15	34	NEUTRAL	
1/24/07	31.65	35		
2/27/07	31.59	41	OUTPERFORM	
4/26/07	33.69	43		
7/19/07	37.18	45		
8/16/07	31.79	43		
9/12/07	37.61	45		

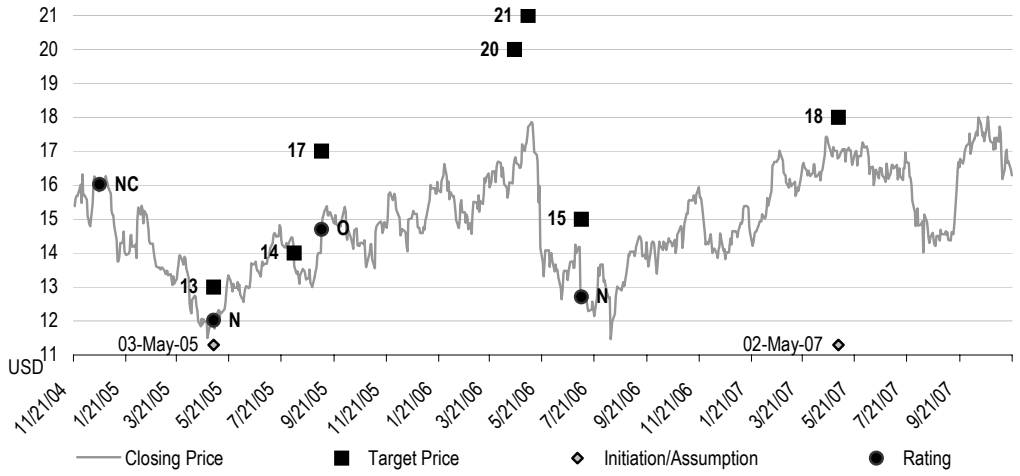
3-Year Price, Target Price and Rating Change History Chart for HPQ



O=Outperform; N=Neutral; U=Underperform; R=Restricted; NR=Not Rated; NC=Not Covered

HPQ Date	Closing Price Price (US$)	Target Price Price (US$)	Rating	Initiation/ Assumption
12/21/04	21.21	22	NEUTRAL	X
7/20/05	24.73	23		
8/17/05	26.82	26		
11/18/05	29.4	30		
2/16/06	34.02	40	OUTPERFORM	
8/17/06	35.15	43		
10/16/06				X
2/15/07	42.68	50		
8/17/07	47.15	52		
11/16/07	50.75	60		

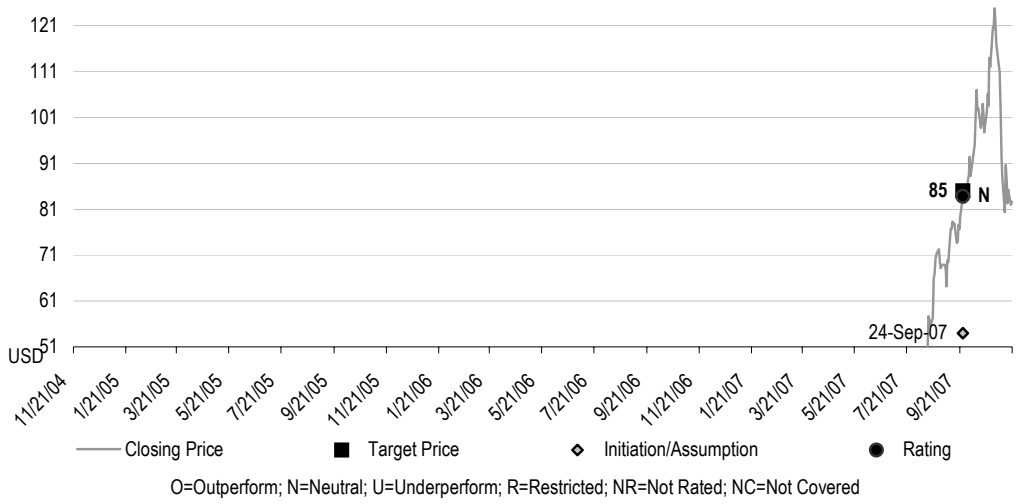
3-Year Price, Target Price and Rating Change History Chart for QSFT



O=Outperform; N=Neutral; U=Underperform; R=Restricted; NR=Not Rated; NC=Not Covered

QSFT Date	Closing Price Price (US$)	Target Price Price (US$)	Rating	Initiation/ Assumption
12/21/04	16.03		NOT COVERED	
5/3/05	12.02	13	NEUTRAL	X
8/5/05	13.62	14		
9/6/05	14.7	17	OUTPERFORM	
4/19/06	16.75	20		
5/5/06	17.72	21		
7/6/06	12.71	15	NEUTRAL	
5/2/07	16.81	18		X

3-Year Price, Target Price and Rating Change History Chart for VMW



O=Outperform; N=Neutral; U=Underperform; R=Restricted; NR=Not Rated; NC=Not Covered

VMW Date	Closing Price Price (US$)	Target Price Price (US$)	Rating	Initiation/ Assumption
9/24/07	83.83	85	NEUTRAL	X

The analyst(s) responsible for preparing this research report received compensation that is based upon various factors including Credit Suisse's total revenues, a portion of which are generated by Credit Suisse's investment banking activities.

Analysts' stock ratings are defined as follows*:**

Outperform: The stock's total return is expected to exceed the industry average* by at least 10-15% (or more, depending on perceived risk) over the next 12 months.

Neutral: The stock's total return is expected to be in line with the industry average* (range of ±10%) over the next 12 months.

Underperform:** The stock's total return is expected to underperform the industry average* by 10-15% or more over the next 12 months.

**The industry average refers to the average total return of the analyst's industry coverage universe (except with respect to Asia/Pacific, Latin America and Emerging Markets, where stock ratings are relative to the relevant country index.*

***In an effort to achieve a more balanced distribution of stock ratings, the Firm has requested that analysts maintain at least 15% of their rated coverage universe as Underperform. This guideline is subject to change depending on several factors, including general market conditions.*

****For Australian and New Zealand stocks a 7.5% threshold replaces the 10% level in all three rating definitions, with a required equity return overlay applied.*

Restricted: In certain circumstances, Credit Suisse policy and/or applicable law and regulations preclude certain types of communications, including an investment recommendation, during the course of Credit Suisse's engagement in an investment banking transaction and in certain other circumstances.

Volatility Indicator [V]: A stock is defined as volatile if the stock price has moved up or down by 20% or more in a month in at least 8 of the past 24 months or the analyst expects significant volatility going forward.

Analysts' coverage universe weightings are distinct from analysts' stock ratings and are based on the expected performance of an analyst's coverage universe* versus the relevant broad market benchmark:**

Overweight: Industry expected to outperform the relevant broad market benchmark over the next 12 months.

Market Weight: Industry expected to perform in-line with the relevant broad market benchmark over the next 12 months.

Underweight: Industry expected to underperform the relevant broad market benchmark over the next 12 months.

**An analyst's coverage universe consists of all companies covered by the analyst within the relevant sector.*

***The broad market benchmark is based on the expected return of the local market index (e.g., the S&P 500 in the U.S.) over the next 12 months.*

Credit Suisse's distribution of stock ratings (and banking clients) is:

	Global Ratings Distribution	
Outperform/Buy*	46%	(58% banking clients)
Neutral/Hold*	40%	(57% banking clients)
Underperform/Sell*	12%	(55% banking clients)
Restricted	2%	

**For purposes of the NYSE and NASD ratings distribution disclosure requirements, our stock ratings of Outperform, Neutral, and Underperform most closely correspond to Buy, Hold, and Sell, respectively; however, the meanings are not the same, as our stock ratings are determined on a relative basis. (Please refer to definitions above.) An investor's decision to buy or sell a security should be based on investment objectives, current holdings, and other individual factors.*

Credit Suisse's policy is to update research reports as it deems appropriate, based on developments with the subject company, the sector or the market that may have a material impact on the research views or opinions stated herein.

Credit Suisse's policy is only to publish investment research that is impartial, independent, clear, fair and not misleading. For more detail please refer to Credit Suisse's Policies for Managing Conflicts of Interest in connection with Investment Research: http://www.csfb.com/research-and-analytics/disclaimer/managing_conflicts_disclaimer.html

Credit Suisse does not provide any tax advice. Any statement herein regarding any US federal tax is not intended or written to be used, and cannot be used, by any taxpayer for the purposes of avoiding any penalties.

See the Companies Mentioned section for full company names.

Price Target: (12 months) for (CTXS)

Method: Target price of $45.00 for CTXS is based on discounted cash flow analysis, which assumes a discount rate of 12% and perpetuity growth rate of 5%, supported by a 27 times price to earnings multiple using our 2008 Pro forma EPS (excluding stock option expense) estimate of $1.67, which is a slight premium to the software median multiple of 23x and with the stock's five-year average multiple of 24x given leadership position of application virtualization market, large installed base, and robust channel program.

Risks: If market fundamentals deteriorate, pricing pressure emerges, or competition from Microsoft, Cisco Systems, Juniper Networks, or f5 increases, our current forecasts may be at risk. If Microsoft enhances its Terminal Services offering to compete more with Citrix at the high end, our price target of $45.00 for CTXS may be at risk.

Price Target: (12 months) for (HPQ)

Method: Our $60 price target for Hewlett-Packard is based on 18 times our fiscal 2008 EPS estimate of $3.37. We believe 18 times price-to-earnings is warranted given our expectation for the company to grow earnings faster than its peers and the broader market.

Risks: Risks to our $60 target price for Hewlett-Packard include market share loss and/or margin pressure in the company's Imaging & Printing Group. However, we believe the company's cost cutting efforts and rebound in supplies growth will enable the company to achieve operating margin in this segment within its long-term target of 14-15%. Another possible issue for the company is execution of its partners as it works to transition it channel partners. Although there will be some transition, we believe the company is proactively working to successfully manage any disruptions. Another risk to our target price is the possibility of the company making a large acquisition. While its cash balance and market value would enable it to make a large transaction, we believe management is more likely to make smaller software and services focused acquisitions.

Price Target: (12 months) for (QSFT)

Method: We rate shares of Quest Software Neutral with a $18 price target. Our price target is based on multi-pronged valuation methodology utilizing both short and long term approaches. Our price target of $18 is based on a 11x next twelve months EV/FCF (enterprise value/free cash flow) multiple on our next twelve months estimate of $140 million, which is a discount to the group average of 16.8 times, which we believe is warranted given the company's product line growth and margin structure.

Risks: Risks to our $18 target price for Quest Software are: As a percentage of revenue the company has diversified its Oracle exposure from 50% of revenue three years ago to the 30%-35% range. Exposure to Oracle can be both a boost and a risk as more sales of the Oracle database help create opportunities but increasingly Oracle is seeking to bundle more of its own management tools in its stack. To minimize this risk, Quest has made several acquisitions to boost its position in on-Oracle environments. Another risk is that it is not perceived as a strategic vendor and therefore could be subject to some vendor consolidation pressure as customers thin the number of providers for management software. While we like the low average deal size attributes of the Quest model, we also realize that it's a double-edged sword that could hurt the company if it is unable to scale up and compete against larger players and infrastructure providers. Given the consolidation in the software market we have some concern that Quest itself might try to roll-up a few vendors to achieve more scale than they could realize on a standalone basis. Smaller, low-risk, technology acquisitions make sense but we think a play for an equal sized competitor would negatively affect the stock in the short-term given the concerns over integration.

Price Target: (12 months) for (VMW)

Method: Our price target of $85 for VMW represents an a EV/CFO (enterprise value to cash flow) multiple of 38x using our 2008 forecast of $800 which is a healthy premium compared to the rest of the industry. We think the premium valuation thoroughly reflects company's market leadership position and growth potential, but makes it difficult for material upside.

Risks: We see a number of risks to our $85 price target: rapidly evolving technology, increasing competition, licensing and technology compatibilities, new products, EMC ownership, and the threat from piracy. VMware's technology is relatively new and still emerging. In addition, the company's products play at the intersection of other rapidly changing technology markets and VMware has to continue innovating while keeping abreast of how peripheral markets are evolving. In addition to increasing competition in general, competing with Microsoft is a unique risk in and of itself given Microsoft's virtually unlimited resources. It is also unclear whether licensing agreements for popular software applications and platforms are compatible with VMware's virtualization products. This uncertainty could result in customers hesitating to purchase virtualization for certain applications. In addition to licensing compatibilities, VMware's software must work seamlessly with different types of hardware and software systems. These systems are constantly changing and sales could be negatively impacted if interoperability issues arise. While VMware has been very

successful in server consolidation, its future revenue growth will, to some extent hinge on selling management solutions. This "up the stack" approach is a naturally extension of its virtualization platforms, but still represents a future challenge and risk for the company. EMC retains a majority ownership in VMware with approximately 98% of the voting power. To the extent there are diverging interests between the 2 companies, VMware's priorities will likely come in second place. And finally, like virtually every software company in the industry today, there is risk that VMware's sales could be impacted due to piracy.

See the Companies Mentioned section for full company names.
The subject company (CTXS, HPQ, QSFT, VMW) currently is, or was during the 12-month period preceding the date of distribution of this report, a client of Credit Suisse.
Credit Suisse provided investment banking services to the subject company (CTXS, HPQ, QSFT, VMW) within the past 12 months.
Credit Suisse provided non-investment banking services, which may include Sales and Trading services, to the subject company (CTXS, HPQ) within the past 12 months.
Credit Suisse has managed or co-managed a public offering of securities for the subject company (HPQ, VMW) within the past 12 months.
Credit Suisse has received investment banking related compensation from the subject company (HPQ, VMW) within the past 12 months.
Credit Suisse expects to receive or intends to seek investment banking related compensation from the subject company (CTXS, HPQ, QSFT, VMW) within the next 3 months.
Credit Suisse has received compensation for products and services other than investment banking services from the subject company (CTXS, HPQ) within the past 12 months.
As of the date of this report, Credit Suisse Securities (USA) LLC makes a market in the securities of the subject company (CTXS, QSFT).

Important Regional Disclosures

An analyst involved in the preparation of this report has visited certain material operations of the subject company (VMW) within the past 12 months. The analyst may not have visited all material operations of the subject company. The travel expenses of the analyst in connection with such visits were paid or reimbursed by the subject company.
The analyst(s) involved in the preparation of this report have not visited the material operations of the subject company (CTXS, HPQ, QSFT) within the past 12 months.

Restrictions on certain Canadian securities are indicated by the following abbreviations: NVS--Non-Voting shares; RVS--Restricted Voting Shares; SVS--Subordinate Voting Shares.
Individuals receiving this report from a Canadian investment dealer that is not affiliated with Credit Suisse should be advised that this report may not contain regulatory disclosures the non-affiliated Canadian investment dealer would be required to make if this were its own report.
For Credit Suisse Securities (Canada), Inc.'s policies and procedures regarding the dissemination of equity research, please visit http://www.csfb.com/legal_terms/canada_research_policy.shtml.

The following disclosed European company/ies have estimates that comply with IFRS: MSFT.

As of the date of this report, Credit Suisse acts as a market maker or liquidity provider in the equities securities that are the subject of this report.

Principal is not guaranteed in the case of equities because equity prices are variable.

Commission is the commission rate or the amount agreed with a customer when setting up an account or at anytime after that.

CS may have issued a Trade Alert regarding this security. Trade Alerts are short term trading opportunities identified by an analyst on the basis of market events and catalysts, while stock ratings reflect an analyst's investment recommendations based on expected total return over a 12-month period relative to the relevant coverage universe. Because Trade Alerts and stock ratings reflect different assumptions and analytical methods, Trade Alerts may differ directionally from the analyst's stock rating.
The author(s) of this report maintains a CS Model Portfolio that he/she regularly adjusts. The security or securities discussed in this report may be a component of the CS Model Portfolio and subject to such adjustments (which, given the composition of the CS Model Portfolio as a whole, may differ from the recommendation in this report, as well as opportunities or strategies identified in Trading Alerts concerning the same security). The CS Model Portfolio and important disclosures about it are available at www.credit-suisse.com/ti.

For Credit Suisse disclosure information on other companies mentioned in this report, please visit the website at www.credit-suisse.com/researchdisclosures or call +1 (877) 291-2683.
Disclaimers continue on next page.

CREDIT SUISSE SECURITIES (USA) LLC
United States of America: +1 (212) 325-2000