

Planning Guide

Desktop Virtualization

Four Key Steps to Planning a Desktop Virtualization Implementation

Why you should read this document:

This guide provides practical information for desktop virtualization planning based on Intel's experience and best practices.

- Categorize users based on a comprehensive list of usage needs and scenarios.
- Evaluate the five primary delivery models against your current business requirements.
- Analyze total cost of ownership based on seven factors, from hardware and software to usability.
- Assess current software vendors to find the right solution for your business.

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Four Steps to Planning a Desktop Virtualization Implementation in Your Organization

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Desktop Virtualization: What It Is (and What It Isn't)

Maybe you started thinking seriously about desktop virtualization only recently, when the head of sales brought in his new tablet device and demanded that it be hooked up to the network—and two dozen more salespeople quickly followed suit. Or maybe you've been thinking about it for several years, since your IT department also began looking at server virtualization.

While it's certainly not a new topic, there's still a lot of confusion about what desktop virtualization is—and what it isn't. At its core, desktop virtualization is a way of reconciling two (often competing) goals: IT's desire to exert more control over the client platform to simplify management and rein in costs, and the user's desire for more flexibility and greater choice in endpoints and applications.

Desktop Virtualization Is...

- Technology that allows multi-client environments to be controlled and managed from a central point.
- A collection of techniques—including streaming, remoting, virtualizing, and layering. Desktop virtualization software solutions apply some or all of these techniques to full desktop images or to applications. The resulting entities are administered and managed by IT through centralized management consoles.
- A way to balance the needs of employees who want to use the devices that help them perform at their best, and the IT department's needs to maintain security, retain management control, and contain costs.
- Technology that can help your IT department be better prepared for what the future brings— for example, putting you in a better position to handle new client OS migrations, the continued proliferation of new client types, and the move to cloud computing.

Desktop Virtualization Isn't...

- A one-size-fits-all proposition. There are multiple delivery models, and it's very likely that the best solution for your company will be a combination of two or more of these models.
- A cure-all for common IT headaches such as reducing the number of images, maintaining security, or managing devices effectively. In fact, if these client management processes are not under control beforehand, desktop virtualization can actually add complexity and reduce IT efficiency.
- A guaranteed way to reduce hardware and support costs. Desktop virtualization is a complex undertaking, and organizations must carefully analyze total cost of ownership (TCO).
- Synonymous with virtual hosted desktops, VDI, or thin clients. Desktop virtualization encompasses both server-side and client-side virtualization options, as well as both thin client and intelligent client options.

The remainder of this planning guide walks through four key steps for planning a desktop virtualization implementation. The information comes from Intel's experience working with desktop virtualization software vendors and OEMs and from our experience analyzing, planning, and implementing desktop virtualization in our own company.

Since 2007, Intel IT has been working with a variety of virtualization techniques to see which would provide the widest range of benefits for Intel. The information in this document is based largely on this experience.

Intel IT Recommends: Best Practices for Client Management

As mentioned, desktop virtualization is not a quick cure for common desktop management issues. In most cases, desktop virtualization still requires a client endpoint and a client operating system that need to be managed and secured. As we've worked on desktop virtualization at Intel, the IT department has found that before embarking on desktop virtualization, it is extremely important to establish proactive, automated client management processes.

We believe that best-practice client management means having the following in place:

- Automated processes for:
 - Password reset
 - Patch management
 - Asset management
 - Antivirus protection
 - Software distribution
- Standardized images
- Minimum possible number of Windows* versions
- PC firewalls
- L1 and L2 lockdown policies
- Network access control

Step 1: Define User Segments and Usage Scenarios

Many IT departments today—including Intel’s—no longer find it feasible to have a single IT service delivery model for their entire user base. This is especially true for desktop virtualization; in most businesses, user needs are too diverse to be covered by a single approach.

The first step in planning for desktop virtualization, then, should be to group users into segments by specific usage scenarios. You can then analyze the right approach to desktop virtualization according to each segment’s particular needs. Intel segmented its user base through a comprehensive user survey; depending on the size of your business, however, you may already have the information you need to create user segments.

The following is a list of usage behaviors and other criteria that will help you group your user base into logical segments.

Category	Usage Needs to Consider
Hardware and peripherals	<ul style="list-style-type: none"> Form factor Input devices Communications devices
Physical work environment	<ul style="list-style-type: none"> Cube or office Bullpen Manufacturing floor or lab Virtual office (mobile)
Online work environment	<ul style="list-style-type: none"> Operating system Business-specific software Data security requirements Performance factors such as compute load, required graphics performance, delay sensitivity, web server load, and so on
Connectivity	<ul style="list-style-type: none"> Wireless Wired Remote access
User expectations for personalization and privacy	<ul style="list-style-type: none"> Personal use of client devices Personal or corporate ownership of client devices Privacy of personal information

Out of this kind of analysis, you can then group users with similar requirements into segments that can be individually addressed. However, always use the fewest number of segments that will meet your requirements. Too much complexity in the planning stages can make a project too difficult or impractical to implement.

To the right are examples of potential user segments. These may fit some scenarios within your organization, but even if they're not applicable to your organization, they provide guidance on how these segments can be constructed.

Segment	Usage Scenario
Office-centric	Uses a stationary office setup within a cube environment and accesses a high number of specialized business applications.
Lab-centric	Works primarily in the organization's lab using a shared workstation, collaborating face-to-face or via a pager.
Power user	Works in a cube environment using a wired connection and a desktop PC equipped with computing- and graphics-intensive applications. Needs to pull large amounts of data from the network.
Traveler	Spends little time in the physical office; most time is spent working from home, traveling, and working from customer sites using a laptop and smartphone equipped with general apps. Tends to be in senior management, with high expectations for personalization and privacy.
Roamer	Moves often among cube, conference rooms, shared workspaces, etc., using a wirelessly connected laptop equipped with general apps.

Step 2: Evaluate the Five Primary Delivery Models

Once you understand the different user segments that need to be served in your desktop virtualization implementation, you can begin evaluating how the different delivery models available stack up against your requirements.

There are five primary delivery models for desktop virtualization.

Server-side virtualization:

- Terminal services
- Virtual hosted desktops

Client-side virtualization:

- Operating system image streaming
- Application streaming and virtualization
- Client-side virtual container

Each model provides some degree of central management, and each has advantages and trade-offs. Keep in mind that the best solution for a given organization typically combines more than one model. But always choose the minimum number of delivery models.

Desktop Virtualization Delivery Models at a Glance					
Model	Terminal Services	Virtual Hosted Desktops	Operating System Image Streaming	Application Streaming and Virtualization	Client-Side Virtual Container
Server- or client-side	Server-side	Server-side	Client-side	Client-side	Client-side
Best suited for	Environments where a critical business application is needed across a broad spectrum of users and when application compatibility and operating system support may be a challenge.	Environments where users have an entire desktop image that needs to be accessed from multiple locations, and the operating system, applications, and workload of that image are stable and predictable.	Environments where security is critical and no user information needs to persist after a session. Also beneficial when local support is a challenge or when uptime is critical.	Environments where application and license deployment/management are critical.	Appropriate for most environments; model is still evolving.
Primary ISV products	Citrix XenApp* Microsoft Remote Desktop Services*	Citrix XenDesktop* Microsoft Virtual Desktop Infrastructure* VMware View*	Citrix XenDesktop	Citrix XenApp Microsoft Application Virtualization* VMware ThinApp*	Citrix XenClient 1.0* Microsoft Enterprise Desktop Virtualization* and Windows Virtual PC 7* MokaFive Suite* Virtual Computer NxTop*

Terminal Services

How It Works

Server-based model. The client is merely a display and input device. All computation is done centrally on the server, and all data is stored in a data center. Nothing is executed or persistent on the client. Users connect remotely to a shared session on a server operating system.

Best Suited For

Environments where a critical business application is needed by users across a broad spectrum of the user base, and application compatibility and operating system support may be a challenge. IT can provide the application as a service without needing testing to ensure compatibility across all platforms and operating systems. Examples: enterprise customer relationship management, finance, and human resources applications.

Endpoint Considerations

This delivery model can be used both with thin clients and intelligent clients.

- Thin clients are most appropriate when users don't need to be mobile; when no user personalization is needed or it can easily be removed by reimaging; and when applications being accessed are not computing- or graphics-intensive.
- Intelligent clients are necessary when the user needs to use applications outside of the terminal services session. Terminal services sessions are not meant to host desktop applications since they run server operating systems.

Before making the thin or intelligent client decision, take into account what type of applications and content users will require not just today, but also two to three years into the future.

Benefits

- **Security:** The operating system, applications, and data never leave the data center.
- **Manageability:** Applications and data are centralized for simpler administration, application management, validation and support, and more reliable backup; user adds, moves, and changes are simple.
- **Costs:** There is a lower cost of incremental software deployment.
- **Access:** Users can access applications from any network-connected client.
- **Disaster recovery and business continuity:** Users can shift to another client or site.

Limitations

- **Performance:** Performance degrades as the number of users per server increases; there can be graphics bottlenecks; the model requires a continuous stream of low-latency bandwidth to maintain display, keyboard, and mouse responsiveness.
- **Software compatibility:** Not all software or specialized peripherals are compatible or suited to this approach.
- **Mobility:** This model requires a persistent network connection with adequate bandwidth.

- **Costs:** New deployments are expensive, including space, servers, software, and networking.
- **Disaster recovery and business continuity:** If server function is lost, processing must shift to a redundant server or data center; loss of network function renders clients inoperable.
- **User satisfaction:** This approach does not provide a PC-like experience in performance, customization, flexibility, and mobility.

Virtual Hosted Desktops

How It Works

Server-based model. The virtual hosted desktops (VHD) model, sometimes called virtual desktop infrastructure (VDI), is similar to terminal services in that all computation and storage is centralized. But with VHD, users have their own complete virtual machine and customized desktop, including the operating system, applications, and settings. To improve the user experience, most VDI protocols have the ability to offload some computing tasks to the client.

Best Suited For

Environments where users have an entire desktop image that needs to be accessed from multiple locations—and the operating system, applications, and workload of that image are stable and predictable. (Requirements need to be well understood to prevent overloading servers.) Example: You need to deliver desktop images to remote, international software developers who work with data and IP that absolutely cannot leave the country of origin.

Endpoint Considerations

This delivery model can be used with both thin clients and intelligent clients.

- Thin clients are most appropriate when users don't need to be mobile; when no user personalization is needed or it can easily be removed by reimaging; and when the applications being accessed are not computing- or graphics-intensive.
- Intelligent clients are most appropriate when rich content and computing- or graphics-intensive applications will be pushed to the client.

Before making the thin or intelligent client decision, take into account what type of applications and content users will require not just today, but also two to three years into the future.

Benefits

- **Security:** The operating system, applications, and data never leave the data center.
- **Manageability:** Desktop image and data management are centralized for simpler administration, application management, validation and support, and more reliable backup; there are reduced image management and storage challenges if using public images instead of private images.
- **User customization:** Allows a more PC-like experience; personalization is possible if private images are used.
- **Access:** Users can access applications from any network-connected client.

- **Hardware/software image validation:** A single "platform" target for all operating system and application images reduces validation efforts.
- **Disaster recovery and business continuity:** Users can shift to another client or site.

Limitations

- **Performance:** Performance degrades as the number of users per server increases; there can be graphics bottlenecks; the model requires a continuous stream of low-latency bandwidth to maintain display, keyboard, and mouse responsiveness.
- **Manageability:** IT must manage, update, and patch virtual desktop images stored in the data center.
- **Software and peripheral compatibility:** Not all software or specialized peripherals are compatible or suited to this approach.
- **Mobility:** VHD requires a persistent network connection with adequate bandwidth.
- **Costs:** New deployments are expensive, including data center space, servers, software, networking, and storage; this is the most server-intensive delivery method.
- **Disaster recovery and business continuity:** If server function is lost, processing must shift to a redundant server or data center; loss of network function renders clients inoperable.
- **User satisfaction:** VHD is unlike the PC experience in performance, customization, flexibility, and mobility.

ISV Products

- Citrix XenDesktop
- Microsoft VDI
- Mware View

Application Level or Image Level?

A helpful way to think of the models and how they fit with your requirements is whether the problem needs to be solved at the application level or image level.

In this case, an "image" is the complete package of the operating system, applications, and user data and settings. Some compute models solve application problems, while others solve image problems.

Application-level models are:

- Terminal services
- Application streaming and virtualization

Image-level models are:

- Virtual hosted desktops
- Operating system image streaming
- Client-side virtual container

For example, an application-level model is likely best suited for a "bring your own computer" implementation, in which end users use their own personal computers at the workplace. In this case, delivering an entire operating system image is likely unnecessary, and streaming only the applications the user needs is sufficient. If an intelligent desktop is used, this approach has the added benefit of enabling users to access their applications even if they can't connect to the network, because the applications remain in cache until users can log in again.

An image-level model is appropriate when you want full control over the image. A fully abstracted image can be centrally managed and then delivered to multiple devices or hosted in the data center. With an image-level approach, you can, for example, equip a contingent worker with everything necessary to complete his or her work, and then completely remove that image when the contract is over.

Operating System Image Streaming

How It Works

Client-based model. No operating system image is installed locally. The operating system is stored and managed in the data center. When the client powers up, a server streams the operating system image to the client over the network. The client uses its CPU and graphics for local execution. The client may be a PC without a hard drive, using main memory exclusively. Application data is stored in a data center.

Best Suited For

Environments where security is critical or no user information needs to persist after a session—in either case, no data is left on the PC after the power is turned off. Also very beneficial where local support may be a challenge or uptime is crucial. Examples: financial task workers like bank tellers, insurance agents, or others who work with secure customer data where mobility is not required; classroom settings, clinic patient rooms, and hospital rooms—a simple reboot gets a fresh operating system image and avoids costly downtime waiting for local support; call center workers who require training using video at their desks—they

can secure the customer data, move independently to another work desk, and access training without leaving the phones.

Endpoint Considerations

This delivery model requires an intelligent endpoint.

Benefits

- **Security:** Application data is stored/protected in the data center; local corruption is removed and patches updated at each boot-up; isolating applications limits data exposure.
- **Manageability:** Desktop image and data management are centralized for simpler administration, application management, validation and support, and more reliable backup; there are reduced image management and storage challenges if using public images instead of private images; licensing is centrally managed; adds, moves, and changes are simple.
- **Performance:** Local execution is virtually identical to locally installed applications; computing- and graphics-intensive performance is good; after boot-up, network demand drops to very low levels.
- **Infrastructure cost:** Fewer and less costly servers are needed; there are reduced storage requirements if using public images; streaming technology has the lowest initial deployment costs of centralized computing models.
- **Disaster recovery and business continuity:** Users can shift to a different site or client; client may continue to function if the server or network is down.

Limitations

- **Security:** At runtime, data and applications are vulnerable to client-side attacks or theft.
- **Performance:** Boot speed can be affected by the distance from server, network load, and number of users.
- **Cost and manageability:** More storage capacity is needed if using private images.
- **Software sequencing process:** Not all software is suitable; initial sequencing setup/debugging can be time- and labor-intensive; streamed and virtualized application interactions can be problematic.
- **Hardware/software image validation:** IT must validate/tune streamed operating systems with each hardware configuration.
- **Disaster recovery and business continuity:** If using private images and the client loses function, manual configuration of a new device may be necessary.
- **Mobility:** There is no off-network or mobile use of a streamed operating system.

ISV Products

- Citrix XenDesktop

Calculating Infrastructure Requirements

Before selecting a particular delivery model for desktop virtualization, you'll want to calculate its infrastructure requirements and determine the level of investment it requires. Infrastructure components to account for include:

- Servers
- Storage

- Data center space, power, and cooling
- Network bandwidth
- Security
- Manageability
- Disaster recovery
- Image and license management

See “Step 3: Analyze Total Cost of Ownership” for more information on calculating infrastructure requirements.

Application Streaming and Virtualization

How It Works

Client-based model. The client operating system is locally installed, but applications are streamed on demand from the data center to the client, where they are executed locally. Streamed apps frequently do not install on the client operating system, but instead interface with an abstraction layer and are never listed in the operating system registry or system files (hence the term “application virtualization”). Interactions between streamed applications, other locally installed software, and the operating system are minimized, eliminating software conflicts. It also can improve security by “sandboxing” applications in isolated containers. Streamed applications can be cached on a laptop and taken off the network. When reconnected, the application can resynchronize with the server to check licensing, version, and usage information, and download new application data to the data center.

Best Suited For

Environments where application and license deployment and management are critical. With application streaming and virtualization, IT can use policies to control when licenses expire, whether the PC is connected to the network or not. Example: setting the license to expire for temporary or contract employees when their contracts have completed. IT can then repurpose the license.

This method of delivering applications is additive to any of the other image delivery models. Applications can be streamed to any operating system, whether it is traditionally installed, virtualized in the data center or on the PC, or streamed.

Endpoint Considerations

While this model can be used with either thin clients or intelligent clients, using an intelligent client has some advantages in mobile usage scenarios. With an intelligent mobile client, users have “offline capability”—they can still access applications resident in the cache even when they can’t connect to the network.

Benefits

- **Security:** Applications are stored and protected in the data center; local corruption is removed and patches are updated at each initiation from the streaming server; isolating applications limits data exposure.
- **Manageability:** Application licensing and provisioning can be streamlined through centralized management; application virtualization may enable legacy applications to run on a newer operating system; reduced conflicts, corruption, and randomness in the operating system registry.

- **Performance:** Virtually identical to locally installed applications; good computing/graphics-intensive performance; after launch, network demand drops to very low levels; reduced network demand versus streaming the operating system; user experience is the same as a standard PC boot.
- **Infrastructure cost:** Fewer/less costly servers needed; streaming technology has the lowest initial deployment costs of centralized computing models.
- **Disaster recovery and business continuity:** Users can shift to a different site or client; users can continue to work offline with cached content.
- **Mobility:** Streamed applications can be cached for off-network use on mobile clients.

Limitations

- **Security:** At runtime, data and applications are vulnerable to client-side attacks or theft.
- **Performance:** Streaming download speeds can be affected by distance from server, network load, and number of users; interactions between virtualized/nonvirtualized applications can be affected.
- **Software sequencing process:** Not all software is suitable; initial sequencing setup/debugging can be time and labor intensive; streamed and virtualized application interactions can be problematic.

ISV Products

- Citrix XenApp
- Microsoft App-V
- VMware ThinAppClient

Client-Side Virtual Container

How It Works

Client-based model. Unlike a locally installed or streamed operating system, the virtual container is abstracted from the platform via a client-based virtual machine manager. Virtual machine images, including the operating system and applications, are created and managed centrally by IT and then delivered to the client, where they are stored and locally executed on a client-based virtual machine manager (VMM). Changes from the client image can be synced with the centrally stored image and vice versa.

Best Suited For

Most environments. Provides mobile users with a centrally managed and secure image. Users get the performance benefits of local execution and IT benefits from centralized manageability. Enables multiple desktop images or work environments on the same PC, with secure isolation between the two environments to prevent cross infection. Examples: office workers who require separate operating environments with differing levels of security and management—for example, a personal and work environment, or a mobile contingent worker with a secured corporate image.

Endpoint Considerations

This delivery model has both Type 1 and Type 2 implementation; both require an intelligent client. In a Type 1 implementation, the VMM requires a thin operating system that runs at the silicon level of the endpoint. In a Type 2 implementation, the VMM requires a full-fledged operating system on the endpoint.

Benefits

- **Security:** With isolated containers, viruses and threats are contained; IT can set policies for each container per users' needs; patches/updates can be deployed on a central corporate image and easily distributed.
- **Manageability:** Operating system images, applications, and data management can be centralized for simpler administration, software migrations, and more reliable backup; image validation is only needed against the VMM; containers are highly portable, with simple installation.
- **Performance:** Subject to VMM efficiency, performance is virtually identical to locally installed applications; good computing/graphics-intensive performance.
- **Mobility:** Containers can be cached and taken off-network; users can carry the container image on a USB drive and run it on any PC.
- **Infrastructure cost:** This model benefits from fewer servers, less storage, and reduced network requirements versus server-side models.

Limitations

- **Security:** At runtime, data and applications are vulnerable to client-side attacks or theft; VMM layer must be protected.
- **Performance:** Running multiple virtual machines on a VMM may cause performance degradation.
- **Maturity:** New model technology, deployment and management tools, and IT processes are still evolving.
- **Industry-wide technical challenges:** Issues needing attention include virtualization of graphics, wireless, power management, docking stations, and peripherals.

ISV Products

- Citrix XenClient
- Microsoft MED-V and Virtual PC 7
- MokaFive Suite
- Virtual Computer NxTop

Additional Delivery Models and ISVs

In addition to the ISVs listed in this section, there are additional vendors whose products don't fit neatly into the five delivery models discussed here. These vendors and products include:

- RES Software* (workspace management)
- Scense* (workspace management)
- Wanova Mirage* (hybrid desktop virtualization)

Step 3: Analyze Total Cost of Ownership

While desktop virtualization can result in cost savings when implemented judiciously, these cost savings are not guaranteed. Any organization considering desktop virtualization should closely analyze the true costs of implementing and maintaining a virtualized desktop environment.

To be useful, any total cost of ownership (TCO) calculation needs to account for all material impacts to the TCO; additionally, the inputs and assumptions of the calculations must reflect the realities of the organization. While vendor-provided TCO and return on investment models can be useful, use them only as a starting point for a more detailed and comprehensive TCO analysis that takes into account the following seven factors:

- Hardware
- Software
- Energy
- Data center real estate
- Support
- Implementation
- Usability

The remainder of this section provides details on each of these factors.

Hardware

Reducing hardware costs is often the driver for organizations to implement virtualized desktops. By moving the computing power to a central and shared location, users who formerly used intelligent desktops can be provided a much lower-cost thin client device to access the shared computing power. However, estimates about the number of virtual users who can share a single server vary significantly—from 6 to more than 70. According to a 2010 published survey from Gartner, most organizations average 6 to 8 users per server, and very few organizations manage to deploy more than 20 users per server.¹

Four primary elements affect hardware costs and the number of virtualized desktop users that can be successfully deployed per server.

- **User type:** User type has a significant impact on the amount of hardware required to successfully virtualize the desktop environment. Users who infrequently access the system or access only small, lightweight applications can share a server in higher numbers than “heavy” users who spend the majority of their day accessing graphics-intensive or analytical systems. Consider deploying different strategies for each user group:

for example, virtualizing “lightweight” users at a different ratio of users per server than knowledge users, and keeping power users in a traditional intelligent desktop environment.

- **Usage spikes:** Another key consideration, often overlooked, is ensuring that the environment can handle spikes in usage as well as day-to-day operations. Usage spikes often occur at key points in sales and financial reporting periods, during key seasonal events, or during “one-off” events such as new product launches. If hardware capacity is planned without considering usage spikes, business may run seamlessly 80 percent of the time but experience significant slowdowns during the business’s most critical periods.
- **Server size:** The size and type of the server has a big impact on the number of virtual users that share a physical server. The important consideration is not the number of servers but rather the total cost to procure, manage, run, and store the servers. Larger, more powerful servers will have a higher up-front cost and cost more to cool, but will hold more users, take up less server floor space, and cost less per virtual user to support.

¹ Dayley, Alan. *User Survey Analysis: Virtualization Cost Reduction and Consolidation Promises Slow in Coming*. Gartner, 2009

- **Disk allocation:** Many of the default values in calculators assume 10 GB of space. In 2009, Gartner concluded that 25 GB is the actual midpoint for most users.¹ But with the proliferation of video, music, and graphic elements in even fairly basic work products, many users are now filling up drives of 100 GB or more and even adding 500 GB USB drives for extra storage. Organizations need to truly analyze and understand the data storage needs of their users before arriving at a conclusion. Different user types may need very different data allocations.

Software

Software licensing costs are often considered in TCO and ROI calculation tools as a potential source of savings. Organizations should be cautious about assuming these savings without a clear understanding of software license agreements. In addition to new software required to run the central servers, most desktop applications charge on a per-user basis and do not allow concurrent user licensing. The end result is often an increase in overall software and software support costs, not a decrease. Many organizations have seen an initial software cost reduction only to discover during software audits that they are in violation of their software agreements, and they end up paying both the full license costs as well as applicable fines. Organizations that virtualize their designers, developers, or other specialty roles often find that these users require an intelligent desktop due to the nonstandard applications they need to run. As a result, two standard licenses are required for each of these users, one for each machine.

Energy

Energy matters not only because of how energy costs affect the bottom line, but also because organizations often investigate virtualization in part because they want to create a sustainable or “green” environment for employees and demonstrate corporate responsibility to customers and shareholders. Assuming thin devices are used to access vertical desktops (versus using an older intelligent PC as a dumb terminal), there can be energy savings at the user point. However, these savings may be balanced by user behavior (do they turn off their computer at night, and are power settings configured to optimize energy consumption?) and the energy burden of running and cooling the new servers. Depending on the organization’s current data center, implementing virtualized desktops may require data center and cooling system upgrades.

Data Center Real Estate

Similar to energy, real estate considerations should not be underestimated when evaluating the TCO of desktop virtualization. Replacing a traditional intelligent client desktop device with a new thin device is unlikely to reduce the real estate requirements of each employee. However, the addition of many new servers will definitely increase the amount of real estate required in the data center. There are possible trade-offs related to data center real estate versus cooling (for example, the denser the servers are racked, the less impact on real estate but the greater the need for cooling), but in general, moving to a virtualized desktop will add additional real estate, security, and other facility-related costs such as maintenance and janitorial costs.

Support

One potential benefit of virtualization is reducing desktop support costs. Because servers can be maintained and controlled in a more effective manner than most traditional intelligent desktop environments, the need for desk-side support should lessen. However, three important elements should be considered when calculating true support savings.

- **Reduced user-side support:** It is more cost-effective to support users remotely than to provide desk-side assistance. While these benefits are normally realized as part of desktop virtualization, organizations can potentially realize similar savings by employing low-cost remote desktop applications that allow support personnel to remotely take control of the end user’s local machine to resolve support issues.
- **Increased cost of support personnel:** The skill set needed to support and maintain virtual desktops is often greater than for supporting and maintaining traditional desktops. Although the total number of support full-time employees (FTEs) may reduce, the average cost per FTE may increase.

¹ Dayley, Alan. *User Survey Analysis: Virtualization Cost Reduction and Consolidation Promises Slow in Coming*. Gartner, 2009

- **Reductions in support problems:** While desktop virtualization may reduce true support inquiries, many support calls are actually “how-to” inquiries. These how-to inquiries will likely increase immediately following the deployment of virtualized desktops. Organizations should analyze and understand their support ticket mix prior to making assumptions about how many of these problems will be solved with virtualization, and also allow for an initial increase in support calls during the rollout and adoption of the new virtualized systems.

Implementation

While most virtualization TCO calculators take into account hardware, energy, and real estate costs, few take into account the investment of IT and third-party resources needed to implement the virtual desktop environment. Three aspects of implementation should be considered.

- **Initial setup:** These are the basic tasks of setting up servers, creating users’ virtual environments, managing the different software applications’ permissions profiles, and porting user data, applications, and documents. These efforts can be very significant and, given that most IT and project departments manage a lean staff, outside contractors or consultants may be needed; these costs should be accounted for in a cost analysis.
- **Legacy applications:** Older software applications may not run in a virtualized environment. Organizations need to consider the cost of updating or replacing these legacy applications as part of (or prior to) a move to a virtualized environment. Depending on the size and complexity of these application upgrades and replacements, these costs can actually overshadow the TCO for desktop virtualization. Several virtualization projects have been derailed as a result of not fully understanding the impact of virtualization on the legacy application stack, and therefore on business productivity.
- **Change management:** Moving to virtual desktops is a significant change for most organizations, which makes end-user training and change management programs essential for a successful implementation. If users will be losing autonomy (such as losing the ability to add personal communication, music, or other programs), a comprehensive change management and communication strategy is essential to help reduce resistance and encourage adoption. An organization’s TCO model should account for these costs.

Usability

Four major components of usability should be considered when analyzing virtualization.

- **Mobility:** The cost of mobile thin client devices and, possibly, wireless broadband Internet connectivity services for mobile workers must be built into the cost model. Questions that organizations should answer include the following:
 - How mobile is the workforce and how available is broadband connectivity where they are?
 - Is there a need to work at home, while traveling on planes or trains, or in hotel rooms?
 - Will they ever need to work offline? Or will mobile users only ever travel to other offices or locations where access to connectivity and thin clients is provided?
 - In addition, will IT support help users who use a personal device at home or while traveling to access their virtual desktop? If so, what are the implications for support needs?
- **Cultural impacts:** Each organization has its own unique culture. Going virtual can challenge many corporate cultures. If the organization is already accustomed to a highly managed intelligent desktop environment, the shift may not be a significant one. However, more than one virtual desktop implementation has failed because users were not prepared to lose the autonomy and freedom their intelligent desktops provided.

-
- **Performance:** Even a properly scaled infrastructure will experience performance issues due to usage spikes, network lag, and underperforming or less-than-optimized servers. All of these can be managed to some degree; usage spikes can be handled with oversizing the hardware; underperforming or less-than-optimized servers and networks can be actively monitored and maintained. While this can improve performance, it also requires additional investment in hardware for usage spikes and additional and skilled IT resources for monitoring and tuning the servers and network. Many network lag issues are the result of third-party services and cannot be avoided even by the best-run IT organizations using top-of-the line equipment.
 - **System/network failure:** Although virtualization can provide a more stable environment than intelligent desktops, it can also magnify server or network failures. The cost of ensuring high availability and system and network redundancy must be included in the TCO analysis. Organizations must also balance the risks of system and network failure and the costs of mitigating that risk against the cost savings of virtualization.

Step 4: Choose the Right Software Vendor

The desktop virtualization ISV landscape is very complex. There are countless interdependencies and relationships, both technological and business related, among the vendors. To complicate matters, some companies offer not only software, but hardware and services as well. The possibilities are many, and so are the software vendors.

However, completing steps 1 and 2 above—segmenting your user base and then analyzing the primary delivery models against your specific business and technical needs—will narrow the field considerably, as will completing your TCO analysis in step 3. This section covers additional factors to take into consideration in making your vendor choice.

Understand the User Experience

Analyze vendor solutions from the perspective of your users. If you implement a particular vendor's solution, what will users experience in terms of performance, capabilities, and ease of use? Taking as little as possible away from the current end-user experience will increase the solution's chances of being accepted by users.

Analyze Your IT Department:

How Mature Is It?

Do an honest evaluation of how automated and process-oriented your IT department is. Does it follow ITIL* best practices? Some vendor solutions for desktop virtualization are quite complex and appropriate only for mature IT departments to implement and maintain. On the other hand, some vendor solutions can be quite straightforward and will help you get to value relatively quickly.

Pilot, Pilot, Pilot

A desktop virtualization initiative crosses many technical and departmental boundaries in an IT organization. Before you commit to a particular vendor solution, it is essential that you do a thorough evaluation in as close to a production environment as possible. Implement proof-of-concept projects and pilots to determine if the vendor solution will meet your business needs.

Features to Look For

In addition to analyzing whether a vendor's delivery model is right for your business, consider further capabilities of the software solution and whether they will meet your needs. Some features to look for are as follows:

- **Enterprise scalability:** How many users can the solution serve?

- **Desktop provisioning:** How do you create, assign, and deliver desktops?
- **Application life-cycle management:** How do you manage licenses and application delivery?
- **Richness of IT policies:** Does the solution offer a rich set of IT policies to control and secure the desktops or applications?
- **Ease of administration:** How many consoles do IT administrators have to work with?
- **Ease of maintenance:** How is the solution itself patched and updated?
- **Infrastructure monitoring:** Does the solution provide a way to measure the performance and health of the infrastructure, including network, storage, servers, and so on?

Intel Resources for Learning More

For additional information from Intel's IT department on desktop virtualization, see the following documents.

Defining Desktop Virtualization

Developing an Enterprise Client Virtualization Strategy

Starting in 2007, Intel IT has been studying a variety of virtualization techniques to see which would provide the widest range of benefits for Intel. We summarize the pros and cons in this paper.

intel.com/content/www/us/en/enterprise-reliability/intel-it-enterprise-client-virtualization-strategy-paper.html

Enabling Device-Independent Mobility with Dynamic Virtual Clients

Intel IT is investigating dynamic virtual client technology, which uses containerized software appliances to abstract the OS; applications; and corporate data, personal data, and workspaces.

intel.com/content/www/us/en/mobile-computing/intel-it-mobile-computing-independent-mobility-dynamic-virtual-clients-paper.html

Benefits of Virtualization

Virtualizing the Client PC: A Proof of Concept

Intel IT conducted a proof of concept and found that desktop virtualization could reduce total cost of ownership by streamlining PC client builds.

intel.com/content/www/us/en/virtualization/intel-it-virtualization-virtualizing-the-client-pc-paper.html

Intel IT Considering Dynamic Virtual Client

In this video, Dave Buchholz, Technology Evangelist, discusses the specifics of how virtual client technology can help companies support IT consumerization while reducing total cost of ownership and improving productivity.

<http://communities.intel.com/docs/DOC-4313>

Selecting the Right Endpoint

Increasing Productivity with Mobile Business PCs

Intel IT conducted a detailed study and compared computing models and devices against our computing requirements. After analysis, we selected mobile business PCs as our standard platform. One key factor was their ability to support emerging technologies such as virtualization.

intel.com/content/www/us/en/mobile-computing/intel-it-mobile-computing-business-pc-paper.html

A New Model of Client Computing

Better Together: Rich Client PCs and Cloud Computing

The Intel IT environment contains a mixture of conventional and cloud computing services, delivered primarily to mobile business PCs. As we add new delivery models such as desktop virtualization, we expect to realize benefits such as increased end-user productivity and lower TCO.

intel.com/content/www/us/en/cloud-computing/cloud-computing-vpro-intel-it-rich-client-pcs-and-cloud-computing-study.html

Evaluating Thin-Client Security in a Changing Threat Landscape

Intel IT conducted a security analysis of thin clients versus mobile business PCs. We found that while thin clients may be suitable for some niche uses, we have chosen mobile business PCs to support the functionality and flexibility our employees require. In addition, mobile business PCs position us to take advantage of the benefits of desktop virtualization.

intel.com/content/www/us/en/enterprise-security/intel-it-enterprise-security-thin-client-paper.html?wapkw=evaluating_thin_client_security

The Future of Enterprise Computing: Preparing for the Compute Continuum

By taking advantage of a combination of technologies and trends, such as ubiquitous Internet connectivity, virtualization, and cloud computing, we have an opportunity to meet changing employee requirements and refine the way we provide services.

intel.com/content/www/us/en/it-management/intel-it-the-future-of-enterprise-computing-preparing-for-the-compute-continuum-paper.html

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