Optimizing virtual desktops and applications to the branch office
Introduction

The challenge of managing applications and desktop environments across the enterprise is becoming more formidable as the range of applications supporting employee productivity and business operations continues to grow. IT organizations are often stretched to the limit performing such routine operational tasks as:

- Deploying applications and application upgrades
- Provisioning new desktop systems
- Installing patches to keep desktop machines and applications up to date
- Securing systems and data from intrusions
- Providing help desk support
- Maintaining control of the desktop environment to ensure demonstrable compliance with regulatory mandates

The increasing percentage of employees located in a branch office or other remote location exacerbates the problem. Since most branch offices have limited or no IT staff, the IT organization must centrally manage each of the tasks listed above for the branch office. Remote locations also often require more stringent security measures due to a lack of physical security and the frequent presence of guests, business partners and other visitors.

Desktop virtualization and application virtualization are two effective technologies that simplify the management of user devices by centralizing the IT tasks listed above. According to industry metrics, virtualizing desktops and applications can reduce the cost of testing, packaging and supporting application delivery by up to 50 percent.

Many large-scale desktop and application virtualization deployments are at central sites where a high speed LAN delivers applications from servers to the client systems. However, with the appropriate virtualization infrastructure, these technologies can also be effectively deployed to support branch office workers and other remote employees.

This white paper analyzes application virtualization technology and shows how branch optimization solutions can overcome distance and bandwidth constraints, and allow IT organizations to fully realize the benefits of desktop and application virtualization.
Overview of desktop virtualization

Virtualization abstracts the physical characteristics of computing resources from the way in which other systems, applications or users interact with those resources. It allows people to use computing capabilities—from a single application to an entire operating system—without being tied to the specific physical hardware or other resources that support those capabilities.

Server virtualization, running multiple environments on a single server, is currently the best known virtualization technology. Desktop virtualization is rapidly growing faster than server virtualization and is quickly gaining momentum as the top IT initiative in organizations today. Desktop virtualization provides users with a complete operating environment, delivered and managed from a central server so that the desktop can be delivered as a service to users anywhere.

As the foundation of a new desktop architecture, desktop virtualization frees IT from many of the costs and constraints of traditional approaches. Management is centralized, eliminating the need for IT staff to travel from endpoint to endpoint, and the storage of all desktop images in a single location improves data security in addition to simplifying backup and recovery. Since they can access their complete desktop environment on-demand, users are no longer dependant on a specific machine and gain tremendous flexibility and convenience in choosing when and where to work.

Hosted desktop virtualization

Hosted desktop virtualization abstracts physical desktops from how users interact with them. The users physically work with their local device (PC or thin client), but the computing environment that they interact with is actually running on a remote system, typically a datacenter server. Any user input (keystrokes, mouse clicks, etc.) is sent across the network to the remote system, and the user interface (i.e., the virtual desktop) is presented back across the network to the user.

Unlike client-server computing and application virtualization—which focus on delivering individual applications—desktop virtualization provides a complete operating environment, including the operating system, applications and data. In addition, unlike systems that provide virtualization on desktop systems, server-based desktop virtualization removes the dependency on specific local PC configurations. Hosted desktop virtualization includes hosted shared desktops, hosted VM-based desktops (VDI) and hosted blade PC desktops.
Desktop Streaming

Desktop streaming enables the centralization of desktop management in the data center for standardized PCs on the LAN. When users turn on their endpoint device, the desktop is streamed from the golden master image and all the processing occurs on the local device. This offers a way to get the TCO advantages of centralization, using minimal server infrastructure, when you have standardized PC hardware or thin clients with the CPU and RAM to run a desktop OS.

![Desktop streaming over the LAN](image)

Figure 2: Streamed desktop virtualization

Overview of application virtualization

Application virtualization centralizes the management of both applications hosted at the central site and delivered over an optimized protocol (hosted application virtualization), and applications that are streamed on-demand to client devices (local application virtualization). In both of these models, the application is virtualized because it is installed in the datacenter, but appears to be installed on the client device. A single application repository that hosts or streams desktops and applications to users dramatically reduces the cost and complexity of managing applications and desktop environments.

Hosted application virtualization

With hosted application virtualization, the application and data reside on a central server farm and the application interface is presented to the user over the network, as shown in Figure 3. Only screen displays, keyboard entries and mouse movements are transmitted across the network using a lightweight delivery protocol. This minimizes the bandwidth required to deliver an application to a remote user. Hosted application virtualization maximizes IT’s central control over both applications and data, and enables rapid delivery of Windows® applications over almost any type of network connection. Hosted application virtualization also does not require the user device to have a full-functioned operating system, allowing desktops to be replaced with lower cost thin client terminals. A primary advantage of hosted application virtualization is that the application can be securely accessed from home computer, airport Internet kiosks, smart phones and other devices external to the enterprise network. From the perspective of mobile users, they can log in to their corporate network over the Internet and securely access all of the applications they would normally use at work.
Local application virtualization (streaming)

Local application virtualization is composed of two primary functions: application isolation and application streaming.

- Application isolation inserts an abstraction layer between the application and the operating system of the client device to encapsulate the application. The virtualized application is isolated both from other applications and from the operating system. This isolation eliminates any possible application conflicts or operating system instability.

- Application streaming delivers a virtualized application to a user device's isolation environment from a centralized application repository or application hub in an on-demand fashion.

The combination of application isolation and application streaming eliminates much of the cost associated with regression testing, certification of applications for regulatory compliance, deployment, maintenance, updates and the de-provisioning of applications running on endpoint devices. Application streaming also lowers support costs by automatically updating and repairing applications every time they are streamed and by enhancing security through control of applications regardless of the user’s endpoint device or network location.
Figure 4 shows the delivery of a streamed application to a user device. Application streaming is selective in the sense that only the required application libraries are streamed to the user's device. The streamed application's code is isolated and not installed on the user device. The user can also have the option to cache the virtual application's code on the user device. Caching greatly reduces the volume of download traffic for streamed applications and is particularly effective for applications that are infrequently updated. Caching also allows applications to be run locally on the client without the use of streaming in the event of network outages or other situations where the user's device lacks network connectivity.

Challenges in extending desktop and application virtualization to the branch office

The primary challenge associated with the delivery of virtualized desktops and applications to branch offices is to ensure adequate levels of performance over the Wide Area Network (WAN) and meet the application experience expectations of the users. Widespread adoption of virtualized desktops and applications requires the ability to deliver a high-performance, personalized experience that is as good as when applications are natively installed on the desktop.

Protocol efficiency

A complicating factor is that the response time for the completion of a task depends on the number of application turns per task and the payload that is transferred per task. As shown in Figure 5, native application protocols such as CIFS, MAPI and HTTP require a large number of application turns and transfer a large amount of data per turn. This slows response times, particularly when WAN bandwidth is limited. Applications that require many application turns per task are also highly susceptible to the effects of high latency and packet loss.

Protocols optimized for hosted desktop and application virtualization (ICA and RDP) are far more efficient in their bandwidth consumption and their response times are correspondingly far less susceptible to latency and packet loss. However, as these protocols have matured, they have been enhanced to transmit more than just lightweight presentation data. For example, they now carry bulk data such as print jobs and files saved to locally mapped drives. This alters their bandwidth profile making them more sensitive to network conditions.

Streamed applications are less efficient than hosted applications on the network, as they use the same protocols that are native to the application (CIFS, MAPI and HTTP). Furthermore, streamed applications create additional challenges for branch offices because a large application package must be streamed across the WAN when the application is initially delivered to the branch.
WAN constraints

All forms of application delivery over the WAN, including virtualized applications, have to cope with the same set of constraints of the WAN as a packet delivery medium:

**Limited WAN bandwidth** – Bandwidth connecting remote offices to central sites is still expensive and generally cannot be provisioned at levels that comfortably accommodate peaks in business activity in spite of some gradual improvement in the price and performance of WAN services. Increasing levels of user and application density within the branch office exacerbates the limited bandwidth problem. When a number of users at the branch office uses the same application over the course of the business day, a large amount of identical data is transmitted repeatedly between the central site and the branch office. Such traffic redundancy can be highly wasteful of limited WAN bandwidth.

As shown in Figure 5, the protocols that support hosted applications and desktops (ICA and RDP) are inherently bandwidth efficient. However, significant levels of traffic redundancy still occur with these technologies when multiple users access the same standardized virtual desktops or print common documents. As previously mentioned, streamed applications are less bandwidth efficient because large data transfers are required when the application is first streamed and every time it is patched.

**Latency** – End-to-end propagation delay is the primary cause of latency over the WAN. High latency limits the potential throughput via transport protocols (e.g., TCP) that require acknowledgements of previously sent packets before additional packets can be forwarded. While latency affects all TCP-based transfers, as noted earlier, users of chatty protocols (i.e., CIFS, MAPI and HTTP) generally feel the greatest effect. Reducing the number of application turns per task is the best approach to mitigate latency.
Packet loss – When packets are dropped or delivered out of order due to congestion in the WAN, TCP reduces its window size and retransmits the lost packets. The result of packet loss is therefore a reduction in bandwidth efficiency and an increase in response time. Like latency, packet loss affects all TCP-based transfers. The effect of packet loss is somewhat magnified for large transfers that use larger TCP windows to transmit data, such as for large file transfers or initial delivery of a streamed application. However, interactive ICA and RDP traffic, which rely on TCP as a transport protocol, can be negatively affected by packet loss.

Adapting WAN optimization techniques to desktop and application virtualization

Over the last few years, most IT organizations have begun to address the challenges that are associated with delivering centralized desktops and applications to branch offices and other remote sites. IT organizations have responded by implementing a variety of solutions that optimize the performance of native (i.e., non-virtual) applications over the WAN. Given the growing interest in deploying both hosted and local desktops as well as application virtualization, traditional WAN optimization techniques are being enhanced to provide similar performance benefits to the delivery of virtualized desktops and applications.

WAN optimization techniques appropriate for virtualized desktops and applications include:

Compression and caching – There are a variety of techniques that can be used to reduce network payloads and thereby reduce bandwidth consumption and user response time. Compression generally involves replacing repetitive data patterns of various lengths by small tokens. Locally caching copies of frequently accessed data and graphics eliminates much of the redundancy in WAN traffic, reducing bandwidth consumption and user response time. Another form of caching is de-duplication, whereby only the changes in previously transmitted data objects are sent over the WAN. Compression, caching and de-duplication benefit hosted and streamed desktops and application usage where there is a high degree of traffic redundancy.

Staging – Pre-positioning large files in the branch office enables IT organizations to deliver these files directly over the LAN when a user requests them. This technique can be used with local application virtualization to reduce the initial launch times and to avoid streaming the application across the WAN multiple times.

Protocol optimization – The inefficiencies of TCP, CIFS, HTTP and MAPI over WAN links with high latency and low bandwidth can be mitigated with protocol optimization techniques. TCP protocol optimization involves making changes to the standard error handling and flow control behaviors (window size and slow start) to improve network efficiency and help mitigate latency issues. TCP optimization benefits both streamed and hosted desktops and applications. Reducing both chattiness and payloads, as shown for CIFS in...
Figure 5, optimizes inefficient application protocols. Application protocol optimization is especially important for streamed applications that make use of native application protocols (i.e., CIFS, HTTP, MAPI) instead of a more efficient protocol such as ICA or RDP.

**Quality of service (QoS)** – Prioritizing WAN traffic can ensure that critical application traffic is given higher priority service, reducing the effects of additional latency due to congestion and resulting packet drops. WAN traffic from both types of virtual applications can benefit significantly from QoS. For hosted desktop and application virtualization, QoS is even more valuable if it can differentiate among and prioritize different virtual channel types used within the delivery protocol (e.g., the screen refresh virtual channel vs. printing virtual channel).

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Table 1: Summary of WAN optimization techniques to desktop and application virtualization

**Taking an end-to-end view of branch optimization**

In addition to deploying these enhanced optimization techniques, IT organizations need to rethink what they want from a desktop and application branch optimization solution. Most optimization solutions available today work in isolation within the network, focusing on just a portion of the overall application delivery system. While this approach provides value, to fully realize the benefits of desktop and application virtualization, IT organizations must implement solutions that work in concert with the entire end-to-end delivery system to apply the right mix of optimization technologies for each situation. For example, protocols such as ICA and RDP incorporate a number of compression techniques including bitmap image compression, screen refresh compression and general data compression. As a result, any compression performed by a branch optimization solution must orchestrate with the hosted virtualization infrastructure to prevent compressing the traffic twice—a condition that can increase the size of the compressed payload and introduce additional latency.
Citrix branch optimization

Citrix® Branch Repeater™ is a branch optimization solution that accelerates virtual desktop and application delivery to globally distributed users while dramatically reducing bandwidth costs and simplifying branch infrastructure. By accelerating application delivery to the branch, Branch Repeater enables IT resource consolidation without compromising the high definition experience that users expect.

HDX IntelliCache and HDX Broadcast

Branch Repeater incorporates two groundbreaking Citrix HDX™ technologies (Figure 6) to optimize both hosted and streamed applications delivered to the branch:

**HDX IntelliCache** – Optimizes performance for multiple users accessing virtual desktops and applications from branch offices by locally caching and de-duplicating bandwidth intensive data and graphics transmitted, and by locally staging streamed application packages.

**HDX Broadcast** – Provides a set of technologies that adaptively tune to real-time conditions to optimize network traffic and deliver a high definition experience for any application regardless of network latencies, bandwidth availability and network reliability.

These complement other HDX technologies found in the datacenter and on the device. Citrix has designed the entire HDX framework to work in concert through innovative adaptive orchestration technology. This process senses the underlying capabilities in the datacenter, network and device, and dynamically applies the best combination of Citrix HDX technologies to ensure a high definition experience to meet each unique user scenario.

Figure 6: Citrix Branch Repeater HDX Technology
Integrated Windows services

Citrix Branch Repeater with Windows Server® further enhances branch optimization and consolidation by including a full-function Windows Server along with Citrix HDX technology for the branch. Branch Repeater with Windows Server consolidates essential services that must remain in the branch office such as file, print, Active Directory (Domain Controller), Domain Name System (DNS) and Dynamic Host Configuration Protocol (DHCP). The approach eliminates the need for an additional dedicated server in the branch office. Branch Repeater with Windows Server also supports Microsoft® ISA Web caching and can act as a secondary site for Microsoft SMS allowing for even greater server consolidation at each branch site.

Citrix Branch Repeater with Windows Server supports native Windows management tools, such as Microsoft System Center Operations Manager and Windows Management Interface (WMI). These management extensions cover all acceleration and optimization functionality in addition to the Windows operating system. This means that the entire branch office infrastructure can be centrally managed with a single set of familiar Windows-based tools.

Conclusion

Desktop and application virtualization offer IT groups an opportunity to further consolidate and centralize their operational tasks by extending the concept of virtualization to include deploying and managing the full suite of Windows application and desktops throughout the enterprise.

As with other styles of remotely accessing centralized applications, virtual desktops and applications face WAN challenges of limited bandwidth, high latency, congestion and packet loss. However, IT organizations can offset these challenges by implementing a comprehensive approach to branch optimization that is based on network-level optimizations adapted for virtual desktops and applications that tightly integrate with the rest of the application delivery infrastructure. Citrix delivers a comprehensive solution for application and desktop virtualization that seamlessly work together to address the entire issue of effectively delivering applications to globally distributed users.
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