Virtualizing Autodesk Revit Architecture 2011

September 2011

Ever since computer aided design (CAD) became feasible on personal computers, architects have been challenged when sharing the workload with others within the enterprise as well as outside consultants and partners. CAD drawings were usually 2-dimensional sheets that represented 3-dimensional objects. Each consultant was responsible for discreet sheets within their field of expertise. The process was messy and inefficient, but delineation of scope was clear. With the emergence of Revit and building information modeling (BIM) on the desktop, new challenges have arisen. Since Revit is model-based and allows multiple users simultaneous access, it is important for all parties to have direct access to the model. It is counterproductive to make copies of the model for the various project constituents as they lose the real-time feedback when changes occur. To overcome these challenges a Revit research partner is experimenting with several virtualization methods to deliver Revit to the far reaches of the enterprise and outside partners and consultants.

The crux of this report will focus on a Revit research partner's experience using virtualization technologies from Citrix. It will attempt to answer the following questions with regard to both inside and outside the Revit research partner's firewall:

1. **What are the mechanical and performance challenges of Revit virtualization?**
2. **What are differences between application virtualization and desktop virtualization?**
3. **What are the access challenges for internal and external users?**
4. **What are the bandwidth requirements for internal and external users?**
5. **What are security issues?**
6. **What are the cost implications?**

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Project Overview/Business Case

Problem Statement

Revit is emerging as the primary BIM tool for architects. To maximize its usefulness, contributors to the BIM model, inside and outside of the enterprise, need secure and fast access to the source model. Between Revit's resource requirements, bandwidth limitations and security concerns traditional methods for sharing BIM data are problematic.

Goal Statement

If properly designed, virtualization technologies from Citrix can deliver Revit to authorized individuals with fast and secure access to the source model; greatly enhancing the quality and speed of completing a Revit- based project.

Project Team

- **Revit Research Partner:** A Revit research partner coordinated the effort, tested the solutions, documented results and provided funding for the hardware necessary to conduct the pilot.

- **ePlus:** ePlus was the technology integrator. They implemented the infrastructure needed to support Citrix XenApp & XenDesktop.

- **Autodesk:** Autodesk is the developer of Revit and major funder for the integration effort.

Scope Definition

The scope of this project includes the testing of (2) Citrix scenarios with a real project that includes multiple parties inside and outside of the enterprise. There were three thrusts to the project:

- **Test Citrix Technologies:** 1.) Application virtualization of Revit, 2.) Desktop virtualization with Revit embedded in the virtual machine.

- **Test Functionality:** Since Revit was not explicitly designed for to run virtualized or concurrently on the same computer or server, we are interested in the practical limitations of using Revit in such an environment.

- **Determine Density Limitations:** How many sessions of Revit can be run simultaneously for a given hardware configuration in each of the (3) scenarios before performance is significantly degraded.

Configuration

Introduction

In order to test the scenarios outlined above, the Revit research partner used several existing servers to support the licensing and database requirements of Citrix, purchased (2) physical servers to deliver virtual desktops (XenDesktop) and virtual apps (XenApp) and utilized (3) virtual servers to handle web server, gateway and desktop delivery roles. The only servers that really matter in regard to Revit performance are the XenDesktop and XenApp servers. All other servers are utilitarian.

Hardware & Software Specs

Following are the hardware and software specs for used for the pilot.

XenDesktop Server

Server Model	Dell PowerEdge R710
Processor	Dual 2.4Ghz Intel Xeon E5620 Quad core Processors
Logical CPUs	16
Memory	48GB 1066Mhz Dual Ranked Memory
Disk Controller	PERC H700 RAID Controller, 512MB Cache
Disk Config	(4) 146GB 15K SAS Disks
RAID Config	RAID 5
Video Card	Matrox M9128 PCIe x16
Video Memory	1GB
Server OS	Windows Server 2008 R2 Enterprise x64
Roles	XenServer (Hypervisor)	XenDesktop Virtual Machines

XenApp Server

Server Model	Dell PowerEdge R710
Processor	Dual 2.4Ghz Intel Xeon E5620 Quad core Processors
Logical CPUs	16
Memory	48GB 1066Mhz Dual Ranked Memory
Disk Controller	PERC H700 RAID Controller, 512MB Cache
Disk Config	(4) 146GB 15K SAS Disks
RAID Config	RAID 5
Video Card	Matrox M9128 PCIe x16
Video Memory	1GB
Server OS	Windows Server 2008 R2 Enterprise x64
Roles	Application Virtualization

Group Policy and Other Settings

Three group polices were applied to the Citrix environment.

1. **XenApp Servers Machine Policy**: The purpose of this policy was to set permissions and segregate Citrix profiles from User Profiles in the XenApp environment.

2. **XenApp Profile Redirection:** The purpose of this policy is to isolate .ini and other user configurable files in the XenApp environment.

3. **XenDesktop User Profile Policy:** The purpose of this policy was to set permissions and segregate Citrix profiles from User Profiles in the XenDesktop environment.

Group Policy 1: XenApp Servers Machine Policy

Links			
Location	**Enforced**	**Link Status**	**Path**

FWR Citrix Servers	No	Enabled	group.hok.com/Firmwide Resources/FWR Citrix Servers
SF XenApp	No	Enabled	group.hok.com/San Francisco/SF XenApp

Security Filtering

The settings in this GPO can only apply to the following groups, users, and computers:

Name

NT AUTHORITY\Authenticated Users

Delegation

These groups and users have the specified permission for this GPO

Name	Allowed Permissions	Inherited
RRP\Enterprise Admins	Edit settings, delete, modify security	No
NT AUTHORITY\Authenticated Users	Read (from Security Filtering)	No
NT AUTHORITY\ENTERPRISE DOMAIN CONTROLLERS	Read	No
NT AUTHORITY\SYSTEM	Edit settings, delete, modify security	No

Computer Configuration (Enabled)

Windows Settings

Security Settings

Local Policies/User Rights Assignment

Policy	Setting
Allow log on locally	BUILTIN\Remote Desktop Users, Power Users, BUILTIN\Administrators
Allow log on through Terminal Services	BUILTIN\Remote Desktop Users, BUILTIN\Administrators

Administrative Templates

System/User Profiles

Policy	Setting
Add the Administrators security group to roaming user profiles	Enabled
Delete cached copies of roaming profiles	Enabled
Log users off when roaming profile fails	Enabled
Wait for remote user profile	Enabled

Windows Components/Internet Information Services hide

Policy	Setting
Prevent IIS installation	Enabled

Windows Components/Terminal Serviceshide

Policy	Setting
Allow users to connect remotely using Terminal Services	Enabled
Enforce Removal of Remote Desktop Wallpaper	Enabled
Remove Disconnect option from Shut Down dialog	Enabled
Remove Windows Security item from Start menu	Enabled
Set path for TS Roaming Profiles	Enabled

Profile path	\\hok-25svr\tsprofiles$
Do not append the user name to the profile path.	Disabled

Policy	Setting
Set the Terminal Server licensing mode	Enabled

Specify the licensing mode for the terminal server.	Per User

Policy	Setting
Show Tooltips for Licensing problems on Terminal Server	Enabled
Use the specified Terminal Server license servers	Enabled

License servers to use:	hok-26vs

Windows Components/Terminal Services/Client

Policy	Setting
Do not allow passwords to be saved	Enabled

Windows Components/Terminal Services/Client/Server data redirection

Policy	Setting
Allow Time Zone Redirection	Enabled

Windows Components/Terminal Services/Encryption and Security

Policy	Setting
Set client connection encryption level	Enabled

Encryption Level	Low Level

User Configuration (Disabled)

Group Policy 2: XenApp Profile Redirection

Links			
Location	**Enforced**	**Link Status**	**Path**
SF XenApp	No	Enabled	group.hok.com/San Francisco/SF XenApp

This list only includes links in the domain of the GPO.

Security Filtering
The settings in this GPO can only apply to the following groups, users, and computers:
Name
NT AUTHORITY\Authenticated Users

WMI Filtering	
WMI Filter Name	None
Description	Not applicable

Delegation		
These groups and users have the specified permission for this GPO		
Name	**Allowed Permissions**	**Inherited**
RRP\Enterprise Admins	Edit settings, delete, modify security	No
NT AUTHORITY\Authenticated Users	Read (from Security Filtering)	No
NT AUTHORITY\ENTERPRISE DOMAIN CONTROLLERS	Read	No
NT AUTHORITY\SYSTEM	Edit settings, delete, modify security	No

Computer Configuration (Enabled)

Administrative Templates

Citrix/Profile Management

Policy	Setting
Enable Profile management	Enabled
Path to user store	Enabled

Absolute path or path relative to the home directory:	\\sf-00svr\SFCitrixProfiles\XenApp\%username%

Policy	Setting
Process logons of local administrators	Enabled
Processed groups	Enabled

Processed groups:
group\domain users
group\RRP Deny Net Access

Citrix/Profile Management/File system/Synchronization

Policy	Setting
Directories to synchronize	Enabled

List of directories to synchronize:
C:\Program Files\Autodesk\Revit Architecture 2011\Journals

Policy	Setting
Files to synchronize	Enabled

List of files to synchronize:
C:\Program Files\Autodesk\Revit Architecture 2011\Program\Revit.ini
C:\Program Files\Autodesk\Revit Architecture 2011\Program\KeyboardShortcuts.txt
C:\Program Files\Autodesk\Revit Architecture 2011\Program\UniformatClassifications.txt
C:\Program Files\Autodesk\Revit Architecture 2011\Data\shxfontmap.txt

System/Group Policy

Policy	Setting
User Group Policy loopback processing mode	Enabled
Mode:	Merge

Windows Components/Terminal Services

Policy	Setting
Set path for TS Roaming Profiles	Enabled
Profile path	\\sf-00svr\SFCitrixProfiles\xenapp
Specify the path in the form, \\Computername\Sharename	

Do not append the user name to the profile path.	

Policy	Setting
TS User Home Directory	Enabled

Location:	On the Network
Home Dir Root Path:	\\sf-00svr\SFCitrixProfiles\XenApp
If home path is on the network, specify drive letter for the mapped drive.	
Drive Letter	Z:

Group Policy 3: XenDesktop User Profile Policy

Links

Location	Enforced	Link Status	Path
SF XenDesktop	No	Enabled	group.hok.com/San Francisco/SF XenDesktop

This list only includes links in the domain of the GPO.

Security Filtering

The settings in this GPO can only apply to the following groups, users, and computers:

Name
NT AUTHORITY\Authenticated Users

WMI Filtering

WMI Filter Name	None
Description	Not applicable

Delegation

These groups and users have the specified permission for this GPO

Name	Allowed Permissions	Inherited
GROUP\Citrix.Install	Edit settings, delete, modify security	No
GROUP\RRP Admins G	Edit settings, delete, modify security	No
RRP\Enterprise Admins	Edit settings, delete, modify security	No
NT AUTHORITY\Authenticated Users	Read (from Security Filtering)	No
NT AUTHORITY\ENTERPRISE DOMAIN CONTROLLERS	Read	No
NT AUTHORITY\SYSTEM	Edit settings, delete, modify security	No

Computer Configuration (Enabled)

Windows Settings

  Security Settings

    Local Policies/Security Options

      Interactive Logon

Policy	Setting
Interactive logon: Do not display last user name	Enabled

Administrative Templates

  Citrix/Profile Management

Policy	Setting
Enable Profile management	Enabled
Path to user store	Enabled

Absolute path or path relative to the home directory:	\\sf-00svr\SFCitrixProfiles\XenDesktop\%username%

Policy	Setting
Process logons of local administrators	Enabled
Processed groups	Enabled

Processed groups:
Group\Domain Users
Group\RRP Deny Net Access

  Citrix/Profile Management/File system/Synchronization

Policy	Setting
Directories to synchronize	Enabled

List of directories to synchronize:
C:\Program Files\Autodesk\Revit Architecture 2011\Journals

Policy	Setting
Files to synchronize	Enabled

List of files to synchronize:

C:\Program Files\Autodesk\Revit Architecture 2011\Program\Revit.ini

C:\Program Files\Autodesk\Revit Architecture 2011\Program\KeyboardShortcuts.txt

C:\Program Files\Autodesk\Revit Architecture 2011\Program\UniformatClassifications.txt

C:\Program Files\Autodesk\Revit Architecture 2011\Data\shxfontmap.txt

System/Group Policy

Policy	Setting
User Group Policy loopback processing mode	Enabled
Mode:	Merge

Windows Components/Terminal Services

Policy	Setting
TS User Home Directory	Enabled
Location:	On the Network
Home Dir Root Path:	\\sf-00svr\SFCitrixProfiles\XenDesktop
If home path is on the network, specify drive letter for the mapped drive.	
Drive Letter	Z:

Citrix Settings: XenApp Console for RAC 2011

Access control	
AGE filters	All AGE connections allowed
Allow connections not through AGE	Yes
Allow connections through AGE	Yes
Appearance	
Color depth	Better Appearance (32-bit)
Hide title bar	No
Maximize at startup	No
⊞ Window size	1024x768
Application type	
Application type	Installed Application
Client options	
Enable legacy audio	No
Enable SSL and TLS	No
Encryption level	Basic
Start without printers	Yes
Enabled	
Enabled	Yes
⊞ **File type associations**	
Limits	
CPU Priority	Normal
Maximum concurrent instances	Unlimited
One instance per user	No
Name	
Application name	RAC 2011-XA6
Description	Revit Architecture 2011 x64
Name	RAC 2011-XA6
Server access location	
Command line	"C:\Program Files\Autodesk\Revit Architecture 2011\Program\Revit.exe"
Working directory	C:\Program Files\Autodesk\Revit Architecture 2011\Program
Shortcut presentation	
Add to client desktop	No
Add to start menu	No
Program Neighborhood folder	
Users	
Anonymous	No

Citrix Settings: XenDesktop Properties

Access Control	
AGE Filters	All AGE connections allowed
Allow Connections Not Through AGE	Yes
Allow Connections Through AGE	Yes
Client Options	
Color Depth	True color
Window Size	Full screen
Desktop Group Settings	
Assignment Type	Pooled
Enabled	
Enabled	Yes
Idle Desktop Count	
Business Hours	2
Out Of Hours	1
Peak Time	4
Idle Pool Settings	
End Time	5:30 PM
Idle Time Zone	(GMT-08:00) Pacific Time (US & Canada)
Peak Period	01:00
Start Time	8:30 AM
Log Off Behavior	
Log Off Behavior	Do nothing
Logon information	
Connection Address	http://172.22.25.151
Hosting Infrastructure	Citrix Xen VM infrastructure (included with XenDesktop)
User Name	root
Name	
Description	
Desktop Group Name	HOK XenDesktop
Display Name	HOK XenDesktop

Citrix Test Infrastructure

CITRIX INFRASTRUCTURE
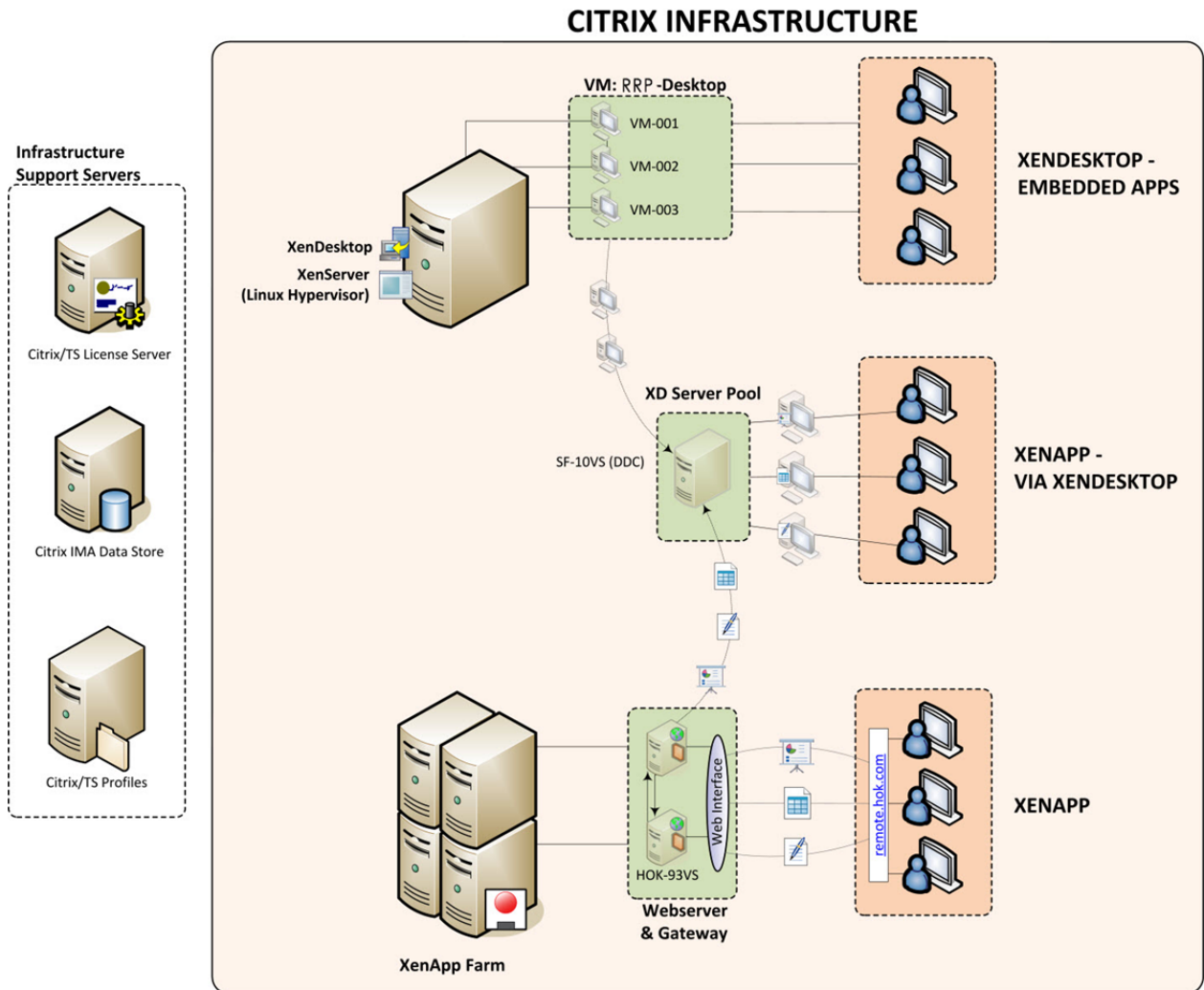
Citrix Technologies: Pros and Cons

XenApp: Pros and Cons

XenApp is a product from Citrix that virtualizes applications for delivery over nearly any internet connection. It virtualizes individual applications rather than an entire desktop.

Pros	Cons
Shared Resources: XenApp enables applications to run multiple times on the same server while sharing resources among the sessions using dynamic resource allocation. Rather than pre-allocating memory to a particular session, XenApp shares it with all sessions.	Complexity: Most apps were not designed for virtualization. Unforeseen challenges will present themselves on a per application basis.
Application Upgrades: When a new version of Revit is released, rather than upgrade each networked computer, only the XenApp servers would require the upgrade. All subsequent virtualized sessions would be based on the new upgrade.	Support: Vendors may deny support. The catch-all response regarding virtualization compatibility is that "it isn't supported". This usually means they haven't tested it, but that it might indeed work fine.
Operating System Independence: By virtualizing the app, the local computer hardware and OS become unimportant. From any type of computer, of any OS, with any browser, the virtual app can be launched. The required plug-in loads automatically and does not need administrative rights.	OS Transparency: Because only the application is virtualized, seemingly simple tasks like browsing the file system can be challenging, but not impossible.
Cost: The total cost of application virtualization is less costly than desktop virtualization, mostly due to differences in computing resource requirements. Application virtualization can also serve as a transitional technology allowing organizations to use existing computers as they move closer to a holistic virtual environment	Offline Computing: Implicit in virtualization is the requirement to be online. This is the biggest trade-off of virtualization. One way around this is through application streaming, which streams the virtualized application to computers. The streamed application would be stored on the local computer; however it would be impractical to steam an entire desktop.
Security: Virtualized apps are isolated from the client OS and from each other, making it nearly impossible for malware to effect the enterprise.	Bandwidth: Our test indicates that a minimum of 250 kb/s is required to maintain an acceptable experience. The ICA will dynamically adjust to bandwidth availability.

XenApp: Revit Architecture 2011 Virtualization Challenges

Application Integration: One of the biggest challenges of application virtualization is integration with other apps. For apps that work well in isolation, this is not a problem. Revit, however, is just one of a suite of apps typically used in a workflow process. In situations where different apps need to "talk" to each other, workflow adjustments are necessary and expectations must be set. For example only one instance of Worksharing Monitor can be run since each virtualized session of Revit is technically on the same server, which means they all share the same machine name.

OS Access: The only access a virtualized application has to the host OS file system is from within the app itself. Windows Explorer is not available directly. In other words, access to files can only be gained from within the Revit GUI.

Printing: Virtualized applications can look and feel like they are on your desktop, giving the illusion that you can print to a local print server. This is only practical, however, if the XenApp servers are on the same subnet as the virtualized application. The more likely scenario is that the print devices are in the subnet where you are physically located while the XenApp servers are in a datacenter or some other central location. Without any formalized thin-printing solution, realistic expectations must be set when printing across the internet or a wide area network.

XenDesktop: Pros and Cons

XenDesktop is a desktop virtualization product from Citrix. It does not virtualize individual apps. Instead it virtualizes entire operating system and all its embedded apps.

Pros	Cons
Resource Utilization Prediction: The utilization of resources under XenDesktop is much easier to predict than XenApp. Each virtual machine is assigned memory and processor resources. For example if 48GB of memory is available on the host server and each virtual machine was assigned 8GB of memory, that server could support exactly (6) session of XenDesktop (6x8=48).	Poor Resource Utilization: Since each VM is assigned a fixed amount of disk space, memory and processor, there is a strict limit to how many sessions can run off of a single server. More advanced hypervisors may have the ability to shift resources around based on actually availability, but Citrix XenServer and Microsoft Hyper-V do not.
Application Integration: Since each VM has its own unique identity, assigned resources and installed apps, there are no conflicts with programs like Worksharing Monitor or batch plotting which appear to identify users based on their machine names.	Patching/Updates: If an office with 100 actual computers converted to 100 virtual computers, you'd still have to secure and patch 100 virtual computers.

XenApp/RAC 2011 Stress Test

All the information presented in previous sections of this document was required to prepare for "stress-testing" both XenApp and XenDesktop. Ultimately, the value of virtualizing Revit can only be realized if a sufficient number of sessions can be run on a reasonably priced server. I refer to this number of sessions as "density". Prior to starting this Citrix/Revit pilot, we made some assumptions about what an acceptable density would be. Traditionally, Citrix experts try to achieve densities into the 100's. Architects, however, intuitively know that this is not a realistic expectation for an app such as Revit. We estimated that 8 sessions per server would allow us to achieve a realistic ROI considering the workstations it could potentially replace and the remote access problems it solves. Following are some specifics of our results.

Testing Scenario

Background: The Revit research partner conducted several tests to understand the mechanical challenges and changes in performance when running Revit multiple times on the same server. The most important test consisted of (5) concurrent sessions. Three participants were in the same location where they shared a high-speed connection to the internet. The 4th participant was tethered to his 3G mobile phone with a 400kbps internet connection and the 5th participant was on a 768k shared DSL connection. None of the (5) users were inside the WAN.

Revit Tasks Performed:
- Navigate 3D views; turn on shadows, etc
- Add and modify walls
- Make groups, nested and arrayed
- Edit floors
- Synchronize with Central

- Edit elements
- Make views and sheets
- Batch print
- Batch export

Baseline Resources: The dual quad-core processors on the server are recognized by Windows as (8) physical processors. When virtualization support is enabled in the Bios, each of those (8) processors is recognized as (2) logical processors. In total it appears to Windows as (16) logical processors. Before the test started, all (16) CPUs were "parked", except for occasional minimal activity on CPU 0 (virtualized Node 0 and Node 1).

Of the 48GB of memory installed, roughly 3GB were use by the host OS and services leaving 45GB available for Revit.

Test Results

Opening Revit: As the first (3) users joined the Citrix session and simultaneously opened Revit, it was observed that equal distribution of CPU utilization occurred across CPU 0 thru CPU 7 (Node 0). Node 1 (the other half of the virtualized processors) remained parked. The overall CPU utilizations never exceeded 5%.

Basic Revit Operations: Each of the (3) users opened the same 80MB Revit model and selected the option "create new local". In a virtual environment, the local file is stored on the XenApp server for all users. As the (3) sessions performed typical Revit operations, both over-all CPU utilization and memory used averaged around 20%. CPU never spiked beyond 30%. Over a period of 20 minutes there was no noticeable difference in Revit performance for any of the users compared to running it locally on a desktop.

Stress Test: After 20 minutes (2) more users logged into Citrix, ran Revit and opened the same 80MB model. Over a 45 minute period, with (5) users simultaneously running resource intensive operations, the overall average CPU utilization was 30% and never spiked beyond 50%. Memory usage held steady at less than 13GB (40% of available memory).

Bottlenecks: The resource most likely to affect the user experience using the internet is bandwidth and latency. Memory would be the next likely challenge; however, with Windows Server Enterprise 2008, you can scale memory to 2TB. The CPUs seems to be the least taxed.

Video Card: Based on our test, the video card was rather unimportant. We did not test for rendering as it was assumed to be inappropriate for this type of environment. There seemed to be no relationship between number of

sessions and video processing as more and more sessions were added. The only noticeable issue (which is somewhat expected due to latency of the internet), were 3D rotations. They would blink off and then reappear once the mouse was released. This was not due to a processing bottleneck, but because of the latency of the internet and the refresh rate of the Citrix client. It was considered acceptable to all users.

Other: The only delays experienced were the same ones experienced by multiple users running Revit on physical desktops (i.e. simultaneous saves to central).

Density Expectations: For the given server configuration, the projected number of Revit sessions that can be run without an appreciable impact on server performance is (15) sessions. It is clear that there is not a one-to-one relationship between running multiple sessions of Revit and utilizing server resources. XenApp's ability to share resources far exceeded our expectations. It should be noted that we did not test multiple models simultaneously on the same server. It is unknown whether this would significantly reduce expected server density.

Recommendations to Make Revit XenApp Aware

Our testing could be divided into two categories. The first category could be called "The Mechanics of Running Revit over XenApp". This would include 1.) Understanding the technologies and effort involved with creating a Revit-friendly XenApp environment. 2.) Proving the ability to virtually deliver multiple sessions of Revit without regard to security or performance. 3.) Uncovering any conflicts/challenges due to the same app running multiple times on single server.

The second category could be called "The Density and Performance Characteristics of Running Revit over XenApp". This would include 1.) Stressing the XenApp server to see how many sessions it could handle before running out of processor and memory resources. 2.) Measure the performance of Revit from the user's perspective as more and more sessions were added.

Recommendations: Mechanics

Worksharing Monitor: The current version of Worksharing Monitor will not allow a second session to run for another user presumably since each Revit session is using the same server name. This should be modified so sessions are allowed "per user", rather than "per machine name" or a combination thereof. This tool is critical to communicate with team members working on a common model and is vital for avoiding simultaneous "saves to central", helping users identify hardware limitations and avoiding losses of work.

Location of User Customizable Config Files: One of the early challenges of running Revit in a multi-user mode was handling the following user-customizable files:

```
…\Program Files\Autodesk\Revit Architecture 2011\Program\Revit.ini
…\Program Files\Autodesk\Revit Architecture 2011\Program\KeyboardShortcuts.txt
…\Program Files\Autodesk\Revit Architecture 2011\Program\UniformatClassifications.txt
…\Program Files\Autodesk\Revit Architecture 2011\Data\shxfontmap.txt
```

Because these files exist within the Revit's program folder, whoever logs out of Revit last over-writes any prior user's customizations. Fortunately Citrix has a profile management tool that can isolate these files per user; however, in future versions of Revit it would be valuable if these files could be part of the user profile. The most useful location within a user's profile would be the "Roaming" folder, so it could follow users that are configured with roaming profiles. This folder exists for all users whether they are configured with roaming or local profiles.

Family Templates: This directory is not accessible to remote Revit users. How can it be made available in an environment where only the Revit app is virtualized?

Batch Printing: Only one session at a time could be run for the Batch Print utility presumably since technically each Revit session is using the same server name. This should allow a session per user, rather than per machine name or a combination thereof.

Journaling by User: It is unknown what the user must do when the Revit application crashes inside a XenApp session. Journal files are difficult to locate and model recovery methods have not been determined. This can be handled by process changes, but perhaps there is a way it could be handled or mitigated within Revit.

Random Revit Extensions Error: Random errors relating to the extensions are popping up even though the extensions are not being run or accessed at all. It is unknown whether this is due to the virtualized environment or a characteristic of RAC 2011.

Loading Content: Users cannot simply navigate to a drive on their own machine. A protocol will need to be established to get around this limitation. Again…this could be handled with a process change, but it also could be mitigated or solved within Revit.

Recommendations: Performance

General: Surprisingly there were no apparent performance issues to due to multiple sessions running on the same server at the same time. However, some interesting behavior was observed depending on what Revit operations were performed. See below.

Positive Performance Example: It was noted that several operations that would typically crash a Revit session on an actual workstation, did not crash when run in this robust server environment. One of the five users printed all views (plans, elevations, sections, details, 3D views, etc) at once, which commonly causes Revit to seize. In this case, not only did it not seize, but it processed the print jobs rather quickly. It is presumed that Revit will use whatever resources are available for this type of operation. There were other operations that behaved differently, however.

Negative Performance Example: Group creation can be an intensive operation. One of the five users created a group made up of 10,000 objects expecting a major spike in server processing and memory resources. Not only did the server not spike…it didn't register ANY resource change. It appears that this operation in Revit has some built-in limit to the resources it uses to complete the operation. It would be useful to identify other operations with the same behavior and make them more "resource aware" so more resources can be used if available.

Multi-Threading Improvements: The XenApp server seemed to do a remarkable job at managing memory resources. Equally impressive, but less understood was how it managed processing resources. Even though Revit is not a fully multi-threaded app and does not scale well across multiple cores the XenApp server registered activity across all (16) logical processors. At times they seemed equally utilized. Other times a processor seemed to have an affinity to a certain session where it would spike to 80% for a few moments, while all the others hovered near 0%. As Revit evolves to better utilize multi-cored CPUs, it would be useful if it could be XenApp aware and adjust to better utilize the vast processor resources available on today's servers.

Video Resources: Surprisingly, video was less of an issue than expected. The precise role the video card plays in a XenApp environment is unclear. Since Revit does not utilize the graphics processor (GPU), the Revit research partner chose a card with 1GB of video memory and no GPU. It is presumed that video memory is tapped before using system memory, but we did not have the tools to verify this. More research is necessary to understand the role and impact of the video card.

XenDesktop/RAC 2011 Summary

Introduction

After several months of learning and testing, it was determined that there is very little that is unknown about the performance characteristics of running Revit in a XenDesktop environment. Revit simply behaves identically within a virtual machine as it does on an actual machine. In regard to density, since XenDesktop assigns fixed resources to virtual machine, it is simply a matter of math. For example, if there are (8) processors and 48GB of available memory and each VM is assigned 6GB of memory and a processor, (8) sessions could be run simultaneously (8 x6=48).

Recommendations: Mechanics

There are no special requirements or recommendations to run Revit within XenDesktop. Since the VM's have unique computer names and are isolated from each other, there are no conflicts with overwriting files or running Worksharing Monitor, etc, as was observed with XenApp.

Recommendations: Performance

Because Revit is run within the virtual machine with a complete OS, it is much easier to integrate with other apps installed within the VM. Of course, the tradeoffs are performance, density and management.

In a XenDesktop environment it is the hypervisor that governs how resources are used, shared or allocated, not XenDesktop. In our test, we used the free hypervisor called XenServer which is not capable of dynamically allocating resources. Microsoft's Hyper-V has the same limitation. Although both are considered Type 1 hypervisors (runs on bare metal hardware), they do not dynamically allocate resources. VMWare's ESX server is the only Type 1 hypervisor I am aware of that can dynamically allocate resources, however, it can be expensive and complex to deploy.

Costs

Introduction

One of the fundamental challenges of this effort was to come up with a scheme that was feasible from a cost perspective. There are (2) aspects to the cost issue. First we needed to determine if the initial investments in hardware and software could be recouped in a reasonable timeframe. Depending on the density achieved consolidating resources onto servers by virtualizing apps vs. distributing workstations and installing "fat" apps could provide a significant cost savings. The second aspect is qualitative…trying to put a value on the solving the speed, access and security problems inherent with remotely accessing enterprise resources. I won't attempt to place a number on this. Instead I will discuss the value it has to the project workflow.

Hardware and Software Costs

XenApp Server Hardware: $6,500

Citrix XenApp Licenses: $ 432 (per concurrent seat)

Return on Investment

	Current Workstation Config	Proposed Low Cost Replacement
Model	Dell Precision T3500	Laptop or Desktop
Processor	Quad Core Xeon W3550, 3.0GHz proc, 8M, L3 4.8GT/s	Single core 2.0Ghz Celeron Processor
Memory	12GB 133MHz, DDR3 SDRAM ECC memory (6 DIMMS)	4GB
Video	512MB NVIDOA Quadro FX580	128MB video memory
Disks	(2) 250GB SATA (RAID 0)	(1) 146GB disk
Cost	$1,600	$500

COST OF RUNNING 15 REVIT SESSIONS	
(15) Traditional Workstations	(1) XenApp Server & (15) Low Cost Clients
$24,000	$14,500
	40% savings*

Other __existing__ servers were used to for web, license and database server roles.

Summary

The goals of this pilot was to determine the feasibility of running Revit in a virtualized environment based on (2) Citrix technologies; XenApp and XenDesktop. The answer appears to be that both are feasible but with pros, cons and cost differences. In general the results were far better than expected. It should be noted that these results are only true for 64-bit environments. The same results should not be expected in 32-bit environments.

We attempted to answer the following questions and did so to varying degrees:

1. **What are the mechanical and performance challenges of Revit virtualization?**

   - We know have much more information on what the challenges are working with Revit in a virtualized environment. In most cases, expectations were exceeded.

   - Revit appears to be much more "virtual" friendly that anticipated.

   - XenApp seems well-suited to handle such a robust app like Revit.

   - With some targeted changes, future versions could become more useful in a virtual environment.

2. **What are differences between application virtualization and desktop virtualization?**

   - We now understand more fully the characteristics of one vs. the other in order to make educated decisions of when to use application virtualization vs. desktop virtualization.

   - In general XenApp provides higher densities and is easier to maintain than XenDesktop, however, resource utilization is more predictable and interoperability with the OS and other apps is more seamless with XenDesktop.

3. **thru 5.**

   What are the access challenges for internal and external users?

   What are the bandwidth requirements for internal and external users?

   What are security issues? This is mainly in regard to outside partners.

   a. Questions 3 thru 5 are of more interest to the Revit research partner than Autodesk as a way to round out the entire value proposition of virtualizing Revit. They relate more to the challenges of working with extended project teams and providing remote access to Revit models inside of the Revit research partner's firewall. We implemented a Citrix secure gateway service to manage access from outside the firewall and a web server service to present the applications. Both servers are free and are included as part of XenApp concurrent licensing.

   b. We now have a better understanding of how bandwidth and latency affect the end-user experience and of the security protocols needed inside of the Revit research partner to safely share internal data with to authorized non-Revit research partner team members.

4. **What are the cost implications?**

   a. Although more testing is required, virtualization of a resource intensive application like Revit appears to offer a feasible alternative to traditional desktop computing.

   b. The performance and density characteristics indicate that hardware costs could be reduced by 40% by delivering applications virtually to inexpensive PC's and ultimately "thin-clients".

   c. More importantly, virtualization technologies like XenApp helps solve a major problem affecting design teams that collaborate on a single model with users inside and outside of the firewall. Even without a quantitative ROI the value this brings to the workflow process and ultimately the accuracy and profitability of a design project cannot be underestimated.