Application Deployment Guide

Autodesk Revit 2015 with NVIDIA GRID vGPU on VMware Horizon

AUTODESK. | NVIDIA. | vmware

THE QUESTION

HOW MANY USERS CAN I GET ON A SERVER?

This is a typical conversation we have with customers considering NVIDIA GRID vGPU:

How many users can I get on a server?

NVIDIA: What is their primary application?

Autodesk Revit 2015.

NVIDIA: Are they primarily architects or designers?

Designers mostly.

NVIDIA: Are their drawing files above or below 200MB?

Above.

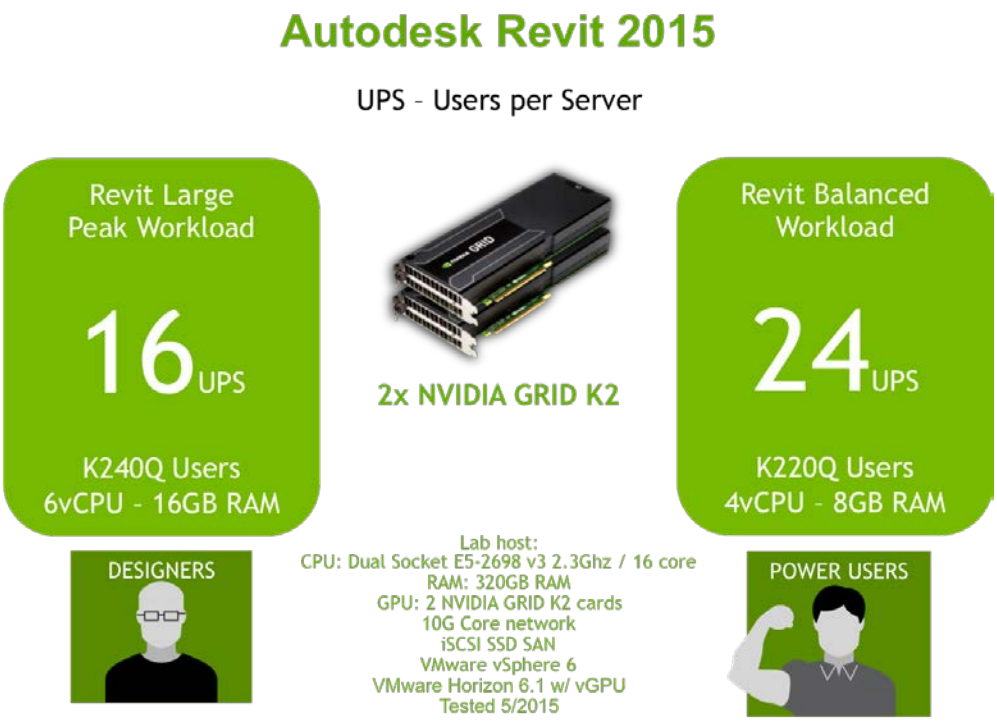
NVIDIA: Power users to designers then.

I need performance AND scalability numbers that I can use to justify the project.

THE ANSWER – USERS PER SERVER (UPS)

UPS – USERS PER SERVER

Based on our findings, NVIDIA GRID provides the following performance and scalability metrics for Autodesk Revit 2015; using the lab equipment shown below, using the RFO benchmark, and in working with Autodesk and their emphasis on usability. Of course, your usage will depend on your models but this is guidance to help guide your implementation.



ABOUT THE APPLICATION: REVIT 2015

Autodesk Revit is Building Information Modeling (BIM) software with features for architectural design, MEP and structural engineering, and construction. Revit requires a GPU as you rotate, zoom, and interact with drawings. It also creates heavy CPU load as it manages all the elements of a drawing via a database, which means we need high performance storage as well. The heaviest Revit CPU usage occurs during data-rich operations like file open/save and model updates. As a result both CPU and GPU need to be considered in architecting your vGPU solution. The size of your drawing file, the concurrency of your users, and the level of interaction with 3D data need to be factored into defining your user groups.

USER CLASSIFICATION MATRIX

Revit classifies its users as follow in Table-01, we then correlate these to our own NVIDIA user classifications as a reference:

Table-01

User Classification Matrix			
NVIDIA User Classifications	**Knowledge Workers**	**Power User**	**Designer**
Revit User Classifications	PM/Mobile	Architect	Power User
Revit File Size	<150MB	150-250MB	700-800MB+
Revit Build Spec	Entry	Balanced	Large

HOW TO DETERMINE USERS PER SERVER

This section contains an overview of the NVIDIA GRID Performance Engineering Lab, our testing, the methodology, and the results that support the findings in this deployment guide. We also detail the lab environment used in our testing.

THE PERFORMANCE ENGINEERING LAB

The NVIDIA GRID Performance Engineering Team's mandate is to measure and validate the performance and scalability delivered via the GRID platform, GRID vGPU software running on GRID GPU's, on all enterprise virtualization platforms. It is our goal to provide proven testing that gives our customers the ability to deliver a successful deployment.

Leveraging its lab of enterprise virtualization technology, the Performance Engineering team has the capacity to run a wide variety of tests ranging from standard benchmarks to reproducing customer scenarios across a wide range of hardware.

None of this is possible without working with ISV's, OEM's, vendors, partners, and their user communities to determine the best methods of benchmarking in ways that is both accurate and reproducible. As a result, the Performance Engineering Team works closely with its counterparts in the enterprise virtualization community.

The NVIDIA Performance Engineering Lab holds a wide variety of different OEM servers, with varying CPU specifications, storage options, client devices, and network configurations. We work closely with OEM's and other third party vendors to develop accurate and reproducible benchmarks that ultimately will assist our mutual customers to build and test their own successful deployments.

TYPICAL AUTODESK REVIT 2015 VIRTUAL DESKTOPS

Autodesk delivers a recommended hardware specification to help choose a physical workstation. These recommendations provide a good starting point to start architecting your virtual desktops. Based on our RFO testing results, along with feedback from early customers, this is our recommended virtual system requirement. Your own tests with your own models will determine if these recommendations meet your specific needs.

VMWARE RECOMMENDED REVIT VIRTUAL SYSTEM REQUIREMENTS

Working with VMware and our shared customers with their tested or production environments, the NVIDIA GRID Performance Engineering Team recommends in Table-02 the following system requirements for deploying Revit in a virtual environment:

Table-02

VMware: Recommended Level Configuration			
VMware Software	VMware vSphere 6 or later w/ VMware Horizon 6.1 or later		
Virtual Machine Operating System	Microsoft® Windows® 7 SP1 64-bit: Enterprise, Ultimate, or Professional Microsoft® Windows® 8.1 64-bit: Enterprise, Pro, or Windows 8.1		
Host Server Recommendation	Minimum	Value	Performance
CPU (Haswell, Intel® Xeon E5 v3, or greater recommended)	2.6 GHz+ Intel® Xeon E5 v2 or greater 2.3 GHz+ Intel® Xeon E5 v3 or greater	3.0 GHz+ Intel® Xeon E5 v2 or greater 2.3 GHz+ Intel® Xeon E5 v3 or greater	3.0 GHz+ Intel® Xeon E5 v2 or greater 2.6 GHz+ Intel® Xeon E5 v3 or greater
Memory	196 GB	256-384 GB	384-512 GB
Networking	1 Gb minimum 10 Gb recommended	10 Gb	10 Gb
Storage	~250+ IOPS Per User	~500+ IOPS Per User	~750+ IOPS Per User
GPU	NVIDIA GRID K1 or later NVIDIA GRID K2 or later highly recommended	NVIDIA GRID K1 or later NVIDIA GRID K2 or later highly recommended	NVIDIA GRID K2 or later
Virtual Machine Settings	Minimum	Value	Performance
Memory	8 GB RAM	8-12 GB RAM	16-32 GB RAM
vCPUs	4 vCPUs	4-6 vCPUs	6-8 vCPUs
Disk Space	Minimum 5 GB free disk space per Autodesk Minimum definition	Minimum 10 GB free disk space per Autodesk Value definition	Minimum 10 GB free disk space per Autodesk Performance definition
Graphics Adapter	NVIDIA GRID	NVIDIA GRID	NVIDIA GRID

	K120Q (512 MB) or later NVIDIA GRID K220Q (512 MB) or later recommended	K140Q (1 GB) or later NVIDIA GRID K240Q (1 GB) or later recommended	K260Q (2 GB) or later
Virtual Machine Connectivity	Internet connection for license registration and prerequisite component download		
End User Access	Each client computer should have the VMware® Horizon Client installed.		

For the test we key on recommended specifications when feasible. The goal is to test both performance and scalability; maintaining the flexibility and manageability advantages of virtualization without sacrificing the performance end users expect from NVIDIA powered graphics.

UX – THE VDI USER EXPERIENCE

To define user experience (UX) requires defining elements of application and user interaction. This can be obvious like the rendering time for an image to appear or smoothly panning across that image. It can also be subtler like the ability to smoothly scroll down a page or the "snappy" reaction for a menu to appear after a right click. While elements such as these can be measured, the user's perception is much harder to measure.

Users also add variables like "think time", the time they spend looking at their display before interacting again with the application. This time offers an advantage to the underlying resources, such as CPU, as it allows tasks to finish and processes to complete. It is even more beneficial in a shared resource environment such as VDI where one user "thinking" frees up resources for another user who chose that moment to interact with their application. Now factor in other time away from the application (meetings, lunch, etc.) and one could expect to get even more benefits from shared resources. These benefits equates to more resources for the user's session and typically a more responsive application, thus a better-perceived experience by the end user.

AUTODESK REVIT BENCHMARK METRICS

Autodesk provides a tool called AUBench which, when combined with the scripts provided via the Revit Forums community, creates a benchmark called RFO. It interacts with the application and an accompanying model to run several tests, then checks the

journal for time stamps, and reports the results. The benchmark is available here: http://www.revitforum.org/hardware-infrastructure/1063-rfobenchmark.html

These tests are meant to represent user activities and are broken down as follows:

Model Creation and View Export Benchmark

- Opening And Loading The Custom Template
- Creating The Floors Levels And Grids
- Creating A Group Of Walls And Doors
- Modifying The Group By Adding A Curtain Wall
- Creating The Exterior Curtain Wall
- Creating The Sections
- Changing The Curtain Wall Panel Type
- Export All Views As PNGs
- Export Some Views As DWGs

Render Benchmark

- Render

GPU Benchmark* with Hardware Acceleration

- Refresh Hidden Line View X12 - With Hardware Acceleration
- Refresh Consistent Colors View X12 - With Hardware Acceleration
- Refresh Realistic View X12 - With Hardware Acceleration
- Rotate View X1 - With Hardware Acceleration

GPU Benchmark* without Hardware Acceleration

- Refresh Hidden Line View X12 - Without Hardware Acceleration
- Refresh Consistent Colors View X12 - Without Hardware Acceleration
- Refresh Realistic View X12 - Without Hardware Acceleration
- Rotate View X1 - Without Hardware Acceleration

* For Hardware Acceleration comparison only.

REAL LIFE EXPERIENCE VERSES BENCHMARKING

Our goal is to find the most accurate possible proxy for testing, but this is still not the same as real users doing real work with their data. The NVIDIA GRID Performance Engineering Labs is committed to working with customers to find more and better models, and field confirmation of findings.

THE IMPORTANCE OF EYES ON!

Its important to view the tests to be sure the experience is in fact something a user would enjoy. That said it's also important to keep perspective especially if you are not a regular user of applications like Revit. While a data center admin deploying a Revit VDI workload might view a testing desktop and think the experience is slow, sluggish, a user who works in it daily might find it normal. An actual 3D designer using the virtual desktop is the ultimate test of success.

TESTING METHODOLOGY

To ensure you will be able to reproduce our results, we have deliberately chosen the Revit Forums RFO Benchmark workload and executed simultaneous tests, meaning all testing virtual desktops are doing the same activities at the same time. A "Peak Workload" should be unrealistic of real user interaction but shows the number of users per host when the highest load is put on the shared resources and therefore gives us the most extreme end of user demand.

- Sample workload: RFO provides their workload, a set of models, for testing with.
- Scripting: As RFO is historically designed for single physical workstation testing, there is no built in automation for multi desktop scalability testing.
- Think Time: By adding a length of time between tests we are making a basic effort to create synthetic human behavior.
- Staggered Start: By adding a delay to the beginning of each test, we are offsetting the impact of tests were they run in unison, again an effort to create synthetic human behavior.
- Scalability: In general we run 1 virtual desktop, then 8, then 16, to get a baseline of results and accompanying logs (CPU, GPU, RAM, networking, storage IOPS, etc.).

RESULTS

The following are results of our testing, looking for the greatest scalability while still within performance expectations. Its important to note that your users, your data, and your hardware, will impact these results and you may decide a different level of performance or scalability is required to meet your individual business needs.

As the RFO Benchmark does not currently exercise some of Revit's newest GPU capabilities, and was built to push the limits of dedicated hardware versus the shared resources of VDI, the decision was made to stop testing once the host's CPU was approaching 100% utilized and test times had climbed past twice what we were finding on the a single physical workstation with dedicated resources. We then met with the Autodesk Revit team, discussed the results, reviewed the tests in action, and determined with eyes on that this was still within what a typical user would deem acceptable and usable.

It's been well documented that storage performance is key to providing high performance graphics workloads, especially with many users and ever-growing file or model sizes. In our lab we were using a 10G iSCSI connected all flash SAN from Pure Storage. At no time in these tests were IOPS an issue, but its important to note that as you scale to multiple servers hosting many guests that this needs to be monitored.

Below are our results with analysis, first on Intel Ivy Bridge processors, then on Haswell. Lower scores are better, representing less time to perform the activity.

Table 1: K220Q performs better than K240Q for Haswell servers (for the RFO models).

Table 2: Significant improvements using Haswell over Ivy bridge – Although Ivy bridge clock speed is higher (3.0 GHz to 2.3 GHz). Haswell also has higher number of logical processors (64 vCPUS) when compared to IB (40), but there is improvement for under-utilized host as well.

Tables 3 & 4: Due to the Staggered start, numbers are slightly better than the previous test runs.

For all cases, CPU only tests (without hardware acceleration) for a single VM takes more time than 16/24 VM tests with GPU (with Hardware acceleration). Which could be due to virtualization overhead. Since these models are quite small, managing larger GPU memory might have a penalty associated with it.

RESULTS SUMMARY

Revit requires significant CPU resources so investing in higer CPU speeds and more cores will pay off on performance and scalability. For medium to large models, K240q

performance might be better for a real use scenario. Your mileage will vary, you must test with your own models to ensure the most accurate results.

RENDER TIMES

The relatively long render times were not seen as an issue as the flexibility of VDI allows you to build up a render specific virtual machine, or for reconciliation, and then redistribute those resources later.

FIELD VALIDATION

These test results were also shared with actual customers and compared to their own testing or production findings which were found to be similar and supporting of these results.

The following are the performance and scalability tests on a host with: Intel(R) Xeon(R) CPU E5-2690 v2 @ 3.0GHz, 20 Cores (2 sockets x 10), 128GB RAM, at Resolution 1920 x 1080 (1080p), running Win 7 Ent SP1 64bit. The last column was a test with CPU clock speed at 2.6GHz, also Ivy Bridge CPU's.

Table-03

# of VDI/Host	1	8	16	16
NVIDIA GPU Profile	K220Q	K220Q	K220Q	K240Q
GPU Allocated Frame Buffer	512MB	512MB	512MB	1GB
VDI Memory	6GB	6GB	6GB	6GB
Host Processor Speed (2x Xeon E5-2690 v2)	3.0Ghz	3.0Ghz	3.0Ghz	2.6Ghz
Host Total Cores	20	20	20	24
vCPUs	6	6	6	6
Model Creation and View Export Benchmark				
Opening And Loading The Custom Template	4.3	4.6	5	5.2
Creating The Floors Levels And Grids	9.6	10.3	11.9	12.75
Creating A Group Of Walls And Doors	29.1	30.9	37.7	38.4
Modifying The Group By Adding A Curtain Wall	58	60.3	70.6	70.4
Creating The Exterior Curtain Wall	17.1	19.1	23.4	23.4
Creating The Sections	10.6	11.6	14.3	14.4
Changing The Curtain Wall Panel Type	7.4	8.3	10.7	10.7
Export All Views As PNGs	27.7	30.3	37.9	38.2
Export Some Views As DWGs	35.7	40	50.6	51
Total	199.5	215.3	262.2	264.6
Render benchmark				

Render	213.2	447.6	884	888.8
GPU benchmark with hardware acceleration				
Refresh Hidden Line View X12	12.5	14.2	22.18	21.6
Refresh Consistent Colors View X12	7.8	9.4	13.6	13.6
Refresh Realistic View X12	9.8	11.7	16.6	16.2
Rotate View X1	4.8	5.8	8.6	8.3
GPU benchmark without hardware acceleration				
Refresh Hidden Line View X12	42.2	62.7	104.4	105
Refresh Consistent Colors View X12	38.3	59	108.6	109.2
Refresh Realistic View X12	41.4	62.1	111	111.4
Rotate View X1	26.8	42.8	68.7	66.3

The following are the performance and scalability tests on a host with: Intel(R) Xeon(R) CPU E5-2698 v3 @ 2.30GHz, 32 Cores (2 sockets x 16), 256GB RAM, at Resolution 1920 x 1080 (1080p), running Win 7 Ent SP1 64bit.

Table-04

# of VDI/Host	1	8	12	16
NVIDIA GPU Profile	K240Q	K240Q	K240Q	K240Q
GPU Allocated Frame Buffer	1GB	1GB	1GB	1GB
VDI Memory	16GB	16GB	16GB	16GB
Host Processor Speed (2x Xeon E5-2698 v3)	2.3Ghz	2.3Ghz	2.3Ghz	2.3Ghz
Host Total Cores (w/ HT)	32	32	32	32
vCPUs	6	6	6	6
Model Creation and View Export Benchmark				
Opening And Loading The Custom Template	3.3	3.63	3.71	3.8
Creating The Floors Levels And Grids	8.6	9.64	10.23	10.18
Creating A Group Of Walls And Doors	22.9	25.69	26.9	27.55
Modifying The Group By Adding A Curtain Wall	44.1	49.36	50.89	51.32
Creating The Exterior Curtain Wall	12.9	14.95	15.95	16.18
Creating The Sections	8.3	9.41	10.18	10.53
Changing The Curtain Wall Panel Type	5.5	6.29	6.78	7.21
Export All Views As PNGs	22.6	25.14	26.39	27.44
Export Some Views As DWGs	27	30.08	31.45	33.37
Total	155.2	174.18	182.49	187.58
Render benchmark				
Render	197.4	301.83	427.53	556.35
GPU benchmark with hardware acceleration				
Refresh Hidden Line View X12	8.9	10.29	10.99	12.59
Refresh Consistent Colors View X12	5.4	6.54	7.03	7.63
Refresh Realistic View X12	7	8.39	9.08	9.88

Rotate View X1	3.2	3.9	4.38	4.66
GPU benchmark without hardware acceleration				
Refresh Hidden Line View X12	27.9	36.09	45.03	51.86
Refresh Consistent Colors View X12	25.4	34.15	45.27	54.09
Refresh Realistic View X12	28.3	36.61	47.32	53.74
Rotate View X1	15	18.99	23.43	23.72

The following results take 8 and 16 columns from the Haswell table above, and add 8 and 16 guest scalability tests where we staggered the test initiation to add a synthetic human element.

Table-05

# of VDI/Host	8	8 - staggered	16	16 - staggered
NVIDIA GPU Profile	K240Q	K240Q	K240Q	K240Q
GPU Allocated Frame Buffer	1GB	1GB	1GB	1GB
VDI Memory	16GB	16GB	16GB	16 GB
Host Processor Speed (2x Xeon E5-2690 v2)	2.3Ghz	2.3Ghz	2.3Ghz	2.3GHz
Host Total Cores	32	32	32	32
vCPUs	6	6	6	6
Model Creation and View Export Benchmark				
Opening And Loading The Custom Template	3.63	3.55	3.8	3.66
Creating The Floors Levels And Grids	9.64	9.15	10.18	9.64
Creating A Group Of Walls And Doors	25.69	25.49	27.55	26.77
Modifying The Group By Adding A Curtain Wall	49.36	49.75	51.32	54.71
Creating The Exterior Curtain Wall	14.95	14.91	16.18	17.04
Creating The Sections	9.41	9.2	10.53	11.43
Changing The Curtain Wall Panel Type	6.29	6.38	7.21	7.59
Export All Views As PNGs	25.14	24.96	27.44	31.56
Export Some Views As DWGs	30.08	30.48	33.37	50.11
Total	174.18	173.86	187.58	212.52
Render benchmark				
Render	301.83	288.85	556.35	445.9
GPU benchmark with hardware acceleration				
Refresh Hidden Line View X12	10.29	11.19	12.59	25.2
Refresh Consistent Colors View X12	6.54	6.8	7.63	12.66
Refresh Realistic View X12	8.39	8.56	9.88	15.08
Rotate View X1	3.9	4	4.66	7.12
GPU benchmark without hardware acceleration				
Refresh Hidden Line View X12	36.09	34.34	51.86	51.13
Refresh Consistent Colors View X12	34.15	33.48	54.09	41.9
Refresh Realistic View X12	36.61	35.6	53.74	41.03

Rotate View X1	18.99	17.91	23.72	22.7

Here are the results when we push for more scalability, bringing the maximum number of VDI guests to 20 and 24. We have added a 15 second staggered start to emulate synthetic human behavior.

Table-06

# of VDI/Host	20	24
NVIDIA GPU Profile	K220Q	K220Q
GPU Allocated Frame Buffer	512MB	512MB
VDI Memory	8GB	8GB
Host Processor Speed (2x Xeon E5-2698 v3)	2.3GHz	2.3GHz
Host Total Cores	32	32
vCPUs	4	4
Test Methodology - staggered start	15 sec	15 sec
Model Creation and View Export Benchmark		
Opening And Loading The Custom Template	3.85	4.15
Creating The Floors Levels And Grids	10.55	11.83
Creating A Group Of Walls And Doors	29.94	33.39
Modifying The Group By Adding A Curtain Wall	61.89	67.23
Creating The Exterior Curtain Wall	19.36	21.85
Creating The Sections	12.12	13.6
Changing The Curtain Wall Panel Type	8.52	9.61
Export All Views As Pngs	34.37	40.7
Export Some Views As Dwgs	46.5	53.33
Total	227.08	255.68
Render benchmark		
Render	620.66	712.23
GPU benchmark with hardware acceleration		
Refresh Hidden Line View X12	20.53	21.83
Refresh Consistent Colors View X12	11.75	12.74
Refresh Realistic View X12	14.16	15.32
Rotate View X1	7.38	7.4
GPU benchmark without hardware acceleration		
Refresh Hidden Line View X12	52.86	60.66
Refresh Consistent Colors View X12	45.84	54.65
Refresh Realistic View X12	45.52	53.49
Rotate View X1	24.85	28.54

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