Pano Logic Pano G2 Running Pano System 4.5: User Experience Performance Testing Competitive Analysis

Test report prepared under contract from Pano Logic

Executive summary

Pano Logic commissioned Sarrel Group to critically evaluate the user experience and performance of virtual desktop thin clients and PCs against the Pano zero client. The two thin clients tested were the Wyse Xenith and the Wyse P20 running Citrix XenDesktop 5 and VMware View 4.6, respectively. There were three PC configurations: Windows XP, Windows 7 32-bit and Windows 7 64-bit on low- and high-performance hardware. Each endpoint solution was evaluated for performance, particularly user experience, server resource utilization, and network utilization. Tests were designed to conduct a fair, repeatable comparison between virtual desktop solutions.

Specifically evaluated were system efficiency CPU consumption, memory consumption, performance, and Quality of Experience (QoE) for three types of workloads:

- Real-world, everyday desktop tasks

- Start-up, restart, and shut-down tasks

- Streaming Flash, Blu-ray, and MP4 video playback

These workloads were evaluated in an isolated switched 1-Gbps Ethernet environment.

We verified the real world application responsiveness for the virtual clients using automated scripts to perform operations in Microsoft Office 2007. We specifically tested performance and QoE using PowerPoint 2007 and Excel 2007.

Overall, we found that Pano G2 outperformed the Wyse Xenith and Wyse P20 in subjective playback experience, and significantly outpaced the Wyse Xenith on everyday tasks.

Key findings

o In MS Office productivity tests, Pano G2 running Pano System 4.5 had the lowest average CPU utilization (25.6%, slightly more than half of the Wyse P20) and lowest maximum CPU utilization of 31.4% during MS Excel Benchmarking. Pano also had the lowest memory consumption of any client (thin client or PC) during MS Excel (lowest maximum) and MS PowerPoint (lowest average) benchmarking.

o Pano G2 running Pano System 4.5 Beta 2 (16.81 sec) outperformed the Wyse Xenith (20.19 sec) and the Wyse P20 (18.97 sec) in tests simulating switching users (warm boot plus login).

o In subjective video quality tests comparing the playback experience of the same video clip in six different formats—full 1080p Blu-ray, 1080p MP4, 1080p Flash video, a 720p MP4, a medium-size Flash video, and a small Flash video—we found that in all but one test, the 720p MP4, Pano G2 delivered a higher quality video playback than the Wyse Xenith and the Wyse P20.

o In full-motion, full-screen video, the new Pano G2 running Pano System 4.5 Beta 2 provides a true real-time video experience versus other tested thin clients, which experience lags and bursts in playback and fail to maintain audio and video synchronization. The experience is comparable as tested against a Windows 7 PC and superior to that of a Windows XP PC.

Pano requires the fewest resources of the thin clients tested in order to provide the best user experience, equivalent to or better than an average corporate PC.

Testing methodology

In order to test under realistic conditions we used an isolated switched 1-Gbps Ethernet network and common server and PC hardware to evaluate zero/thin client VDI solutions from Wyse and Pano Logic. All metrics were gathered in all test scenarios:

- o **Time to Complete:** the time required to run through the complete scenario for scenarios that aren't entirely due to timing length of the content or script

- o **Memory Usage:** min, max, average

- o **CPU Load:** the peak and average server load observed during each test scenario run

- o **Observed Display Issues:** the number of display tearing, distortion, or other artifacts seen during test, manually observed and recorded

Test Procedures

We tested typical office worker usage scenarios using AutoIT-scripted procedures for working with MS Office documents, and starting and restarting the client. The Video QoE testing did not require AutoIT.

AutoIt v3, commonly used and generally accepted in general software test procedures, is a freeware BASIC-like scripting language designed for automating the Windows GUI and general scripting. It uses a combination of simulated keystrokes, mouse movement, and window/control manipulation to automate tasks in a way not possible or reliable with other languages (e.g., VBScript and SendKeys). AutoIt is also very small and self-contained, and it runs on all versions of Windows out of the box with no "runtimes" required.

MS Office Productivity Testing

MS Office productivity testing was conducted to determine the relative performance of each zero/thin client solution. Workloads were designed to stress screen redraw with complex images, gradients, and textures. Scrolling through slide shows and spreadsheets are typical office worker use cases that demonstrate the performance differences between solutions evaluated.

- **PowerPoint Executive/Complex Slide Show Scenario:** This test simulates a user presenting a Pano System master slide deck with high-fidelity slides by using PowerPoint 2007 automated slide show option. This test also uses script that automates the opening and start of a PowerPoint slide show that contains photos, diagrams, animations, and backgrounds with color gradients. The slide show displays each slide for 3 seconds.
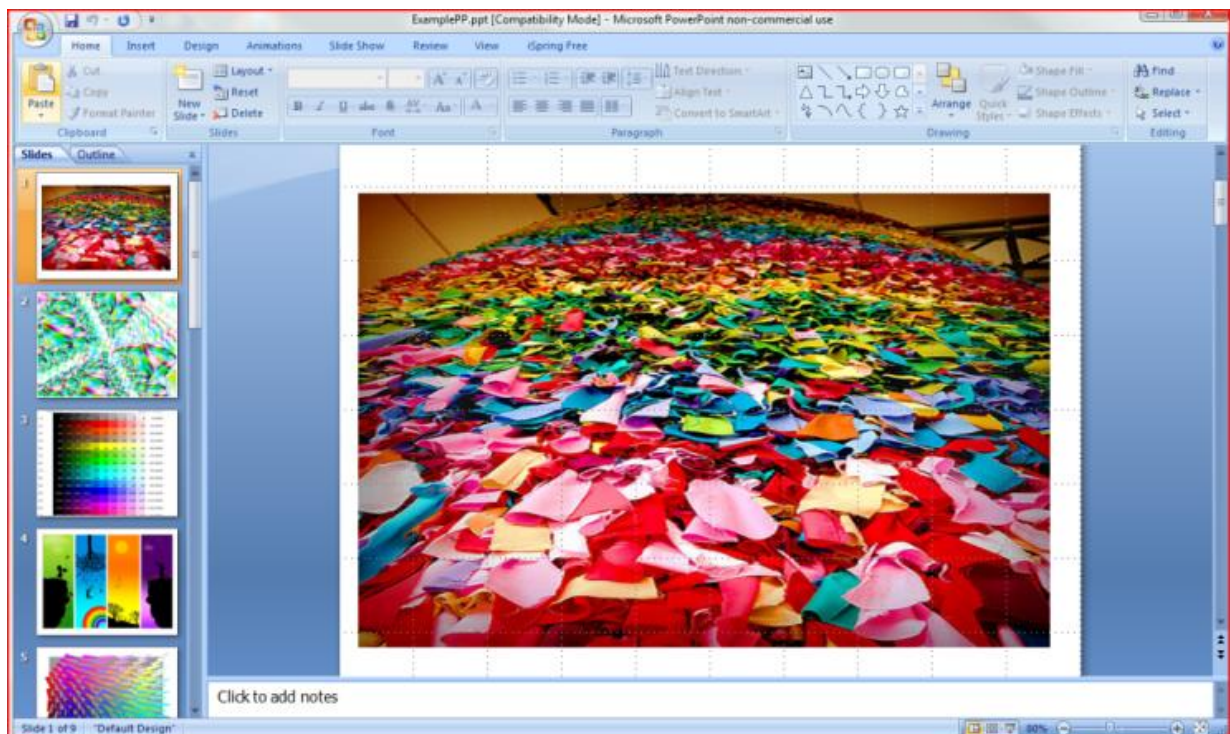
- **Excel Scrolling Scenario:** This test simulates a user working with Excel 2007 using a script with following actions:

  o Open an Excel Data Set in an XLSX file with 151 rows and 98 columns

  o Resize the Excel window to full-screen

  o Select all cells

  o Scroll down using the down-arrow key to the end of document and then back up to the top three times

  o After completing the scrolling, close the file and shut down Excel

Sarrel Group

User Experience
Performance Testing
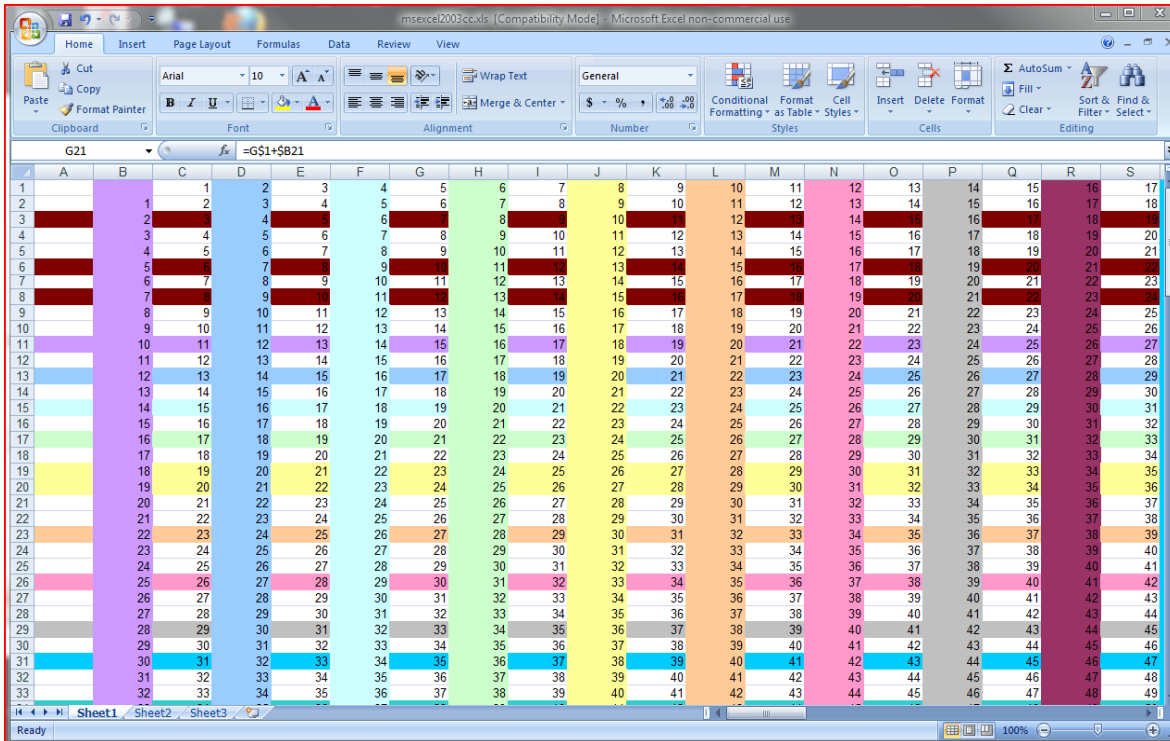
Startup/Shutdown/Restart Testing

We manually timed the following activities with a stopwatch. To accurately determine the role of the thin client solution in these timings we waited two minutes between test runs to allow the DVM to finish operations.

- **Time to Cold-Start:** the time required to reach the client login screen from a client side power-off state. This was accomplished by physically cycling power to each zero/thin client device or PC (removing and reinserting the power cord).

- **Time to Warm-Start:** the time required to reach the client login screen from a client side power-on state after disconnecting from DVM. This was accomplished by logging out of the DVM and recording the time taken by the zero/thin client to reach a client login screen.

- **Time to Desktop:** the time to reach a Windows desktop after completing the login screen. This is the time taken from entering credentials on the login screen until the user is presented with a responsive Windows desktop from the DVM.

Video QoE Testing

The quality of user experience (QoE) for video playback was assessed subjectively using a single stimulus quality comparison scale as described in Recommendation ITU-R BT.500-11, "Methodology for the subjective assessment of the quality of television pictures." This is a generally accepted methodology for measuring video quality degradation. Raters viewed a series of videos across the platforms and used a five-grade impairment scale to measure degradation in video quality. A rating of 5 indicates flawless video and a rating of 1 indicates a choppy video with multiple visual and audile defects. Video playback was assessed in multiple scenarios:

- **Multi-Media HD Video Playback Scenario:** simulates a user viewing the HD video from the VMworld 2009 customer testimonials (filename: PanoLogicEventLoop_1_BD_720p24.mp4). The video is played by Windows Media Player (version 12.0.7600 on Windows 7). The video contains a 3 minute 45 second MP4 video at 24 frames per second at a resolution of 1280 by 720 pixels with a 192 Kbps audio track (3,991 kbps bitrate). This scenario emulates a multimedia redirection for a user viewing a downloaded video file.

- **Multi-Media Flash Video Playback Scenario:** simulates a user viewing a short, variable bit-rate Adobe Flash-encoded video stored locally to eliminate network contention from the test measurements. The video is played within Internet Explorer 8 by an embedded Flash player plug-in. This tests Flash multimedia acceleration.This scenario emulates users viewing video from Web pages such as a YouTube. The resolution of the Adobe Flash video should be 640 by 480 (for 4:3) or 1280 by 720 (for 16:9) pixels.

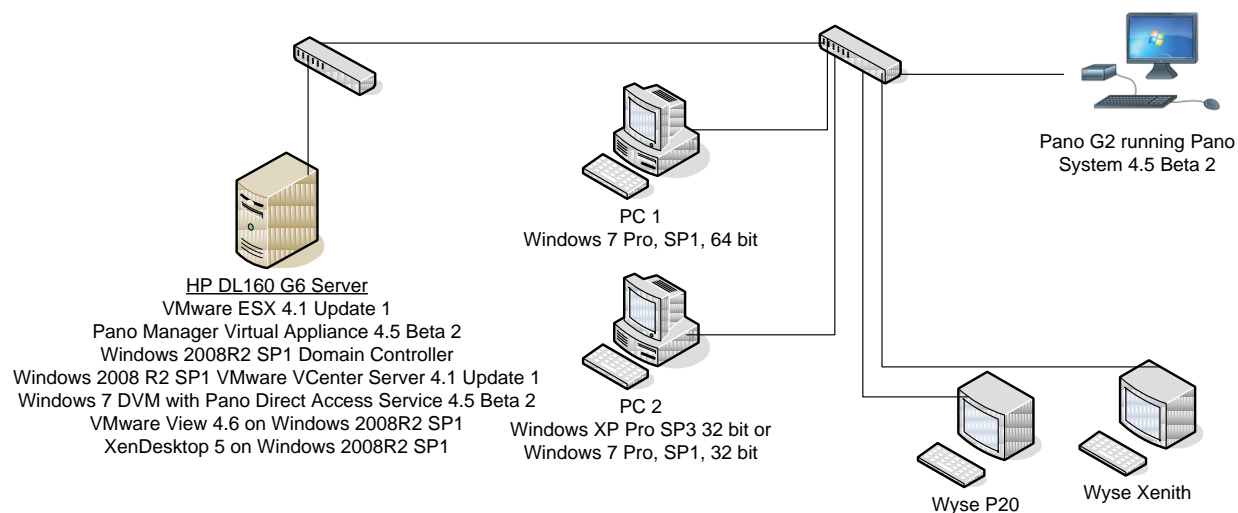Please consult Appendix A for detailed test methodology.

Test Environment Configuration

Virtual desktop clients were evaluated in a switched 1-Gbps Ethernet environment. An HP DL 160 G6 server ran all virtual machines, hypervisors, and management software. The Pano G2 running Pano System 4.5 Beta 2, Wyse P20, Wyse Xenith, and both Windows PCs were connected to a single switch. A SPAN port and WireShark were used to capture all traffic flowing between server and clients.

The server was configured for VMware View 4.6 for the Pano System and the Wyse P20. In addition, the Wyse Xenith required Citrix XenDesktop 5. The Wyse devices are locked into specific virtualization platforms whereas the Pano Solution runs on either.

Please consult Appendix B for detailed hardware configurations.

A schematic of our complete test environment appears below:

Pano G2 running Pano
System 4.5 Beta 2

PC 1
Windows 7 Pro, SP1, 64 bit

HP DL160 G6 Server
VMware ESX 4.1 Update 1
Pano Manager Virtual Appliance 4.5 Beta 2
Windows 2008R2 SP1 Domain Controller
Windows 2008 R2 SP1 VMware VCenter Server 4.1 Update 1
Windows 7 DVM with Pano Direct Access Service 4.5 Beta 2
VMware View 4.6 on Windows 2008R2 SP1
XenDesktop 5 on Windows 2008R2 SP1

PC 2
Windows XP Pro SP3 32 bit or
Windows 7 Pro, SP1, 32 bit

Wyse P20

Wyse Xenith

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Test results

o Pano G2 running Pano System 4.5 Beta 2 outperformed the Wyse P20 and Wyse Xenith in many tests and provided a comparable experience to using a typical Windows XP or Windows 7 PC during most tests.

o Pano had the lowest average CPU utilization (25.6%) and lowest maximum CPU utilization (31.4%) during our MS Excel benchmarking. This average CPU utilization is slightly more than half that of the Wyse P20.
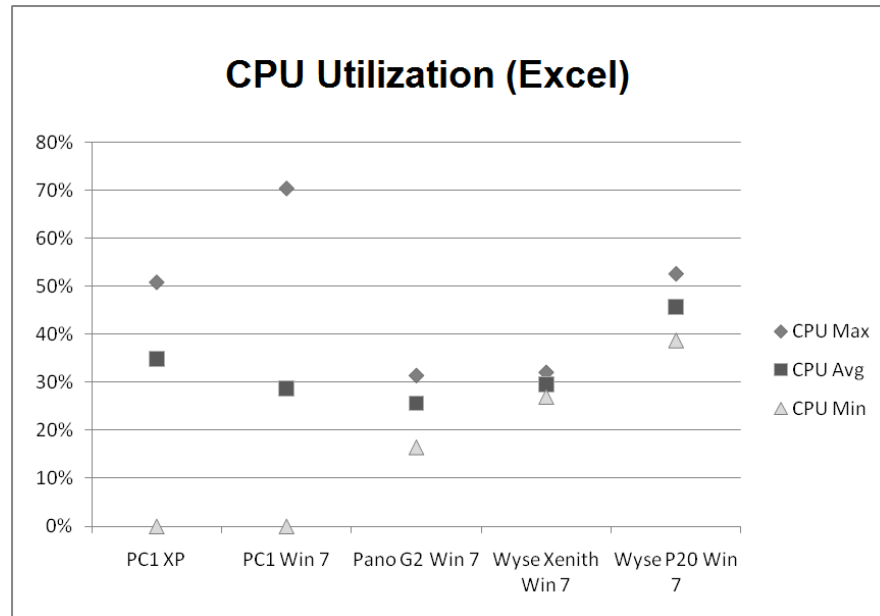
o Pano also had the lowest memory consumption of any client (thin, PC) during MS Excel (the lowest maximum memory consumed) and MS PowerPoint (the lowest average memory consumption) benchmarking.
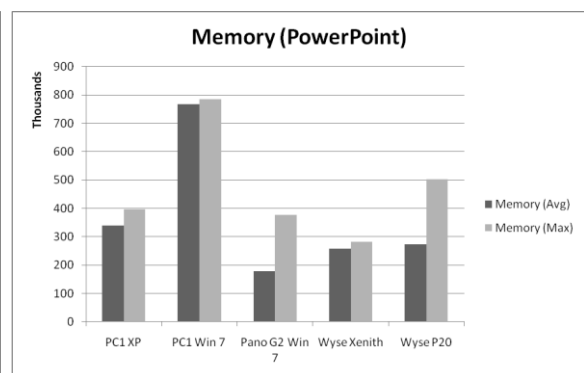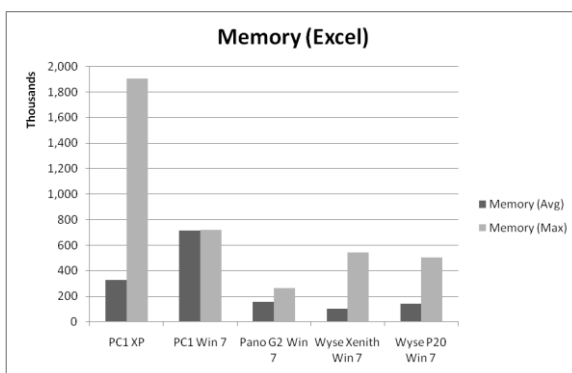
o The Wyse Xenith exhibited visual distortion of items on screen during these tests. For example, icons and menu choices appeared fuzzy or blurry within Microsoft Office applications. A possible explanation is that this is due to lossy compression used to optimize the video traffic between the DVM running on the server and the thin client.

Subjective Video Quality Test Results

- o In all but one test—the 720p MP4—Pano delivered a higher quality video playback than the Wyse Xenith and the Wyse P20.

- o Across all of the 1080 clips, Pano scored better than the Wyse Xenith and Wyse P20, both of which were on par with the Windows XP PC. Pano scored 3.0 vs. 1.7.

- o The average Flash video score has Pano in the lead, exceeding the quality of experience on PC 1, our reference workstation. Pano (4.0) was followed by the Wyse Xenith (3.3) and the Wyse P20 (2.0).

- o Although no zero/thin client provided a high quality MP4 video playback experience, Pano scored 2.5, on par with the PC2 running Windows XP, while the Wyse Xenith scored 1.0 and the Wyse P20 scored little better, with a 1.5. PC 1 and the PC 2, both running Windows 7, scored 4.0.

Results from Visual Qualitative Tests

- o In full motion, full screen video, the Pano provides a real-time video experience versus the thin clients tested which experience lags and bursts in playback and fail to maintain audio and video synchronization. The experience is comparable as tested against a Windows 7 PC and superior to that of a Windows XP PC.

Subjective Video Quality Assessment		
Single Stimulus Quality Comparison Scale		
5-Grade Impairment Scale		
Score	Meaning	Interpretation
5	imperceptible	perfect/reference
4	perceptible but not annoying	notice defects but not bothered
3	slightly annoying	will watch it but don't like it
2	annoying	you could make me watch it
1	very annoying	I refuse to watch this. It makes me sick.

	PC 1 (Win 7)	PC 2 (Win 7)	PC 2 (Win XP)	Pano G2	Wyse Xenith	Wyse P20
1080 Full Blu-ray	5	5	1	3	1	2
1080 MP4	4	4	1	2	1	1
1080 FLV	4	4	3	4	3	2
avg 1080	**4.3**	**4.3**	**1.7**	**3.0**	**1.7**	**1.7**

Subjective Assessment of Video Quality at 1080 Resolution. Higher is better.

	PC 1 (Win 7)	PC 2 (Win 7)	PC 2 (Win XP)	Pano G2	Wyse Xenith	Wyse P20
1080 MP4	4	4	1	2	1	1
720 MP4	4	4	4	3	1	2
avg MP4	**4.0**	**4.0**	**2.5**	**2.5**	**1.0**	**1.5**

Subjective Assessment of Video Quality for MP4 Playback. Higher is better.

	PC 1 (Win 7)	PC 2 (Win 7)	PC 2 (Win XP)	Pano G2	Wyse Xenith	Wyse P20
1080 FLV	4	4	3	4	3	2
Medium FLV	3	3	3	4	3	2
Small FLV	3	3	3	4	4	2
avg FLV	**3.3**	**3.3**	**3.0**	**4.0**	**3.3**	**2.0**

Subjective Assessment of Video Quality for Flash Video Playback. Higher is better.

Time to Complete Task: We evaluated the amount of time each system took to:

o **Cold Start:** Simulates an office worker turning the client on and waiting for a desktop

  o **Results**: The Wyse Xenith (12 seconds) was fastest, followed by the Wyse P20 (28 sec), the Pano G2 (30 sec), and finally the Windows XP (45 sec) and Windows 7 (54 seconds) PCs.

  o **Key Takeaway:** Pano G2 increases productivity by taking office workers from 0 to 60 in roughly half the time it takes for a Windows 7 PC to boot.

o **Warm Start:** Simulates an office worker logging out of a virtual desktop and waiting to be prompted with a new log in screen

  o **Results:** PC 2 running Windows XP achieved the fastest time at 2.5 seconds, All platforms under test completed warm start in under 10 seconds.

  o **Key Takeaway:** Pano G2 can warm start (log off and be ready to log back in as typical when switching users) in under 10 seconds.

o **Desktop:** Simulates an office worker logging in and waiting for the desktop to appear

  o **Results:** The PCs are the fastest at getting to a desktop after a login, followed by the Pano G2 (7 sec), the Wyse Xenith (14 sec), and the Wyse P20 (14 sec).

  o **Key Takeaway:** Pano G2 provides users with a fast login experience, taking roughly 1/2 of the time it takes the Wyse Xenith to go from login to desktop.
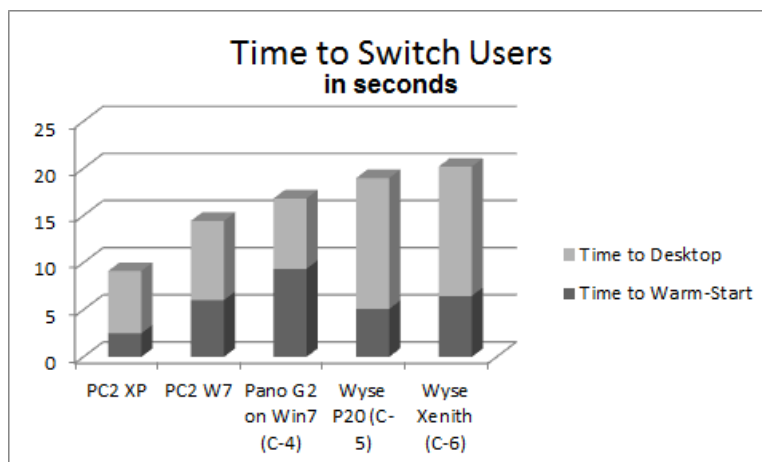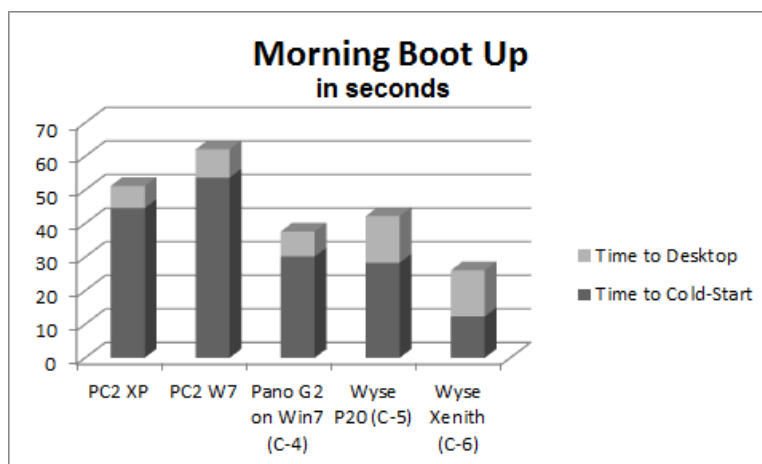
Appendix A. Complete Test Methodology

Test Process

A) Comparability: The test results need to be comparable both across client and server platform combinations and against future tests. To make test results as comparable as possible:

    a. Any client, server or DVM setting that can be, should be the same among all platforms.

    b. The software, clients, PCs and servers used for testing should be stored or their configurations documented so the same platform configurations can be used in future tests.

B) Test Runs: Each set of Test Measurements (Section 5B) should be collected for five consecutive runs and the measurements for the last three sets are averaged.

C) Test Warm-up: Measured test runs should be immediately preceded by three unmeasured test runs to ensure that any server components are at a steady-state.

D) Single Clients Only: Due to resource and time constraints along with the costs of obtaining the required number of client hardware, all test runs will be done with only a single client. This will not provide any information or relative nonlinear server load increases or contention between multiple clients on the server or network. Based on this initial set of single client test runs, a smaller set of multiclient test scenarios may be run later.

E) Test Automation: To ensure tests are repeatable and comparable, an automated test scripting tool should be used, installed in and run from within the Windows DVM (or on the client PC for native Windows and PC based clients).

Test Measurements

The following two types of test measurements will be

A) Test Measurements per Combination: The following test measurements should be collected once for each Test Combination (Section 2) – these may need to be manually timed with a stopwatch:

    1) **Time to Cold-Start:** time required to reach the client login screen from a power-off state

    2) **Time to Warm-Start:** time required to reach the client login screen from a power-on state after disconnecting from DVM

    3) **Time to Desktop:** time to reach Windows desktop after completing login screen

In order to accurately determine the role of the thin client solution in these timings we waited two minutes between test runs to allow the DVM to finish operations.

B) Test Measurements per Scenario: The following test measurements should be collected for each Test Scenario (Section 6) in each Test Combination (Section 3)—where possible these should be automatically timed by the automated test tool:

    1) **Time to Complete:** time required to run through the complete scenario for scenarios that aren't entirely due to timing length of the content or script.

    2) **Server Load:** peak and average server load observed during each test scenarios run.

    3) **Observed Display Issues:** number of display tearing or other artifacts seen during text. This should be manually observed and recorded—will video tape monitor screen and later playback test session at reduced speed to capture correct artifact count.

Test Scenarios

Test scenarios are performed using manual or video capture of results.

1) **PowerPoint Executive/Complex Slideshow Scenario:** simulates a user presenting Pano System master slide deck with high-fidelity slides by using PowerPoint 2007 automated slideshow option. Uses script that automates opening and start of PowerPoint slideshow. The slides contain photos, diagrams, animations, and backgrounds with color gradient. The slide show settings displays each slide for 3 seconds.

2) **Excel Scrolling Scenario**: simulates a user working with Excel 2007. Uses script with following actions:
   a. Open a Excel Data Set in an XLSX file with 151 rows and 98 columns
   b. Resize the Excel window to be full-screen
   c. Scroll down using the down-arrow key to the end of document and then back up to the top three times.
   d. After completing the scrolling, the file is close and Excel is shut down.

3) **Multi-Media HD Video Playback Scenario:** simulates a user viewing the HD video from the VMworld 2009 customer testimonials (filename: PanoLogicEventLoop_1_BD_720p24.mp4). The video is played by Windows Media Player (version 12.0.7600 on Windows 7). The video contains a 3 minute 45 second MP4 video at 24 frames per second at a resolution of 1280 by 720 pixels with a 192 Kbps audio track (3,991 kbps bitrate). This scenario is used to test multimedia redirection for a user viewing a downloaded video file.

4) **Multi-Media Flash Video Playback Scenario:** simulates a user viewing a short variable bit-rate Adobe Flash-encoded video stored on locally to eliminate network contention from the test measurements. The video is played within Internet Explorer 8 by an embedded Flash player plug-in. This scenario emulates users viewing video from Web pages such as a YouTube video. The resolution of the Adobe Flash video should be 640 x 480 (for 4:3) or 1280 x 720 (for 16:9) pixels. Tests Flash multimedia acceleration.

Appendix B. Hardware and Software Specifications

PC 1 (Professional Workstation Reference PC, Dell Precision T3500)

- o 6-core Intel Xeon W3680 CPU running at 3.33 GHz
- o 6GB RAM
- o Two 500 GB 7200 RPM SAS drives configured for RAID1
- o NVIDIA Quadro NVS 295 graphics card

PC2: IBM ThinkCentre S50 SFF

- o Windows XP Prof, SP3, 32-bit or Windows 7 Ultimate, SP1, 64-bit
- o E6300 Core 2 Duo
- o PCI Small Form Factor (2x3)
- o Intel GMA 3000
- o 16x DVD-ROM
- o Intel Gigabit Ethernet
- o 2GB RAM

HP DL160 G6

- o Dual E5620 quad-core Xeon CPU
- o 48GB RAM
- o Seven 10K rpm SAS drives in a single RAID5 volume

DVM Configuration—the following settings were used in the Windows DVMs for each platform:

- o vCPU: 2
- o RAM: 2GB
- o Windows XP Professional SP3 32-bit or Windows 7 Enterprise SP1 32-bit

Peripheral Configuration—the following peripherals and settings were used with each client platform:

- o USB keyboard and mouse
- o Single Viewsonic monitor with either DVI (if endpoint has a native DVI port) or VGA (if client only has a VGA port); display resolution set to 1900x1080 and 16-bit color in Windows or via client software

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