



The science behind the report:

Get a mobile thin client that delivers great unified communications experiences

This document describes what we tested, how we tested, and what we found. To learn how these facts translate into real-world benefits, read the report [Get a mobile thin client that delivers great unified communications experiences](#).

We concluded our hands-on testing on June 9, 2023. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on March 27, 2023 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Our results

To learn more about how we have calculated the wins in this report, go to <http://facts.pt/calculating-and-highlighting-wins>. Unless we state otherwise, we have followed the rules and principles we outline in that document.

Table 1: Results of unified communications end-user experience testing in Citrix® Virtual Apps and Desktops™ 7, VMware® Horizon® 8, and Windows 365 Cloud PC VDI environments.

	HP Elite mt645 G7 Mobile Thin Client	Dell™ Latitude™ 3420 business laptop	Percent difference
Citrix Virtual Apps and Desktops 7 VDI environment			
Audio (receiving) bitrate (kbps) [higher is better]	8.91	10.36	-14.00%
Audio (sending) bitrate (kbps) [higher is better]	7.73	12.64	-38.84%
Audio (receiving) latency (ms) [lower is better]	1.91	1.00	-91.00%
Audio (sending) latency (ms) [lower is better]	1.91	1.00	-91.00%
Audio (receiving) jitter (ms) [lower is better]	1.73	N/A	-
Audio (sending) jitter (ms) [lower is better]	N/A	N/A	-
Video (receiving) bitrate (kbps) [higher is better]	69.45	108.00	-35.69%
Video (sending) bitrate (kbps) [higher is better]	139.18	168.27	-17.29%
Video (receiving) latency (ms) [lower is better]	1.91	1.00	-91.00%

	HP Elite mt645 G7 Mobile Thin Client	Dell™ Latitude™ 3420 business laptop	Percent difference
Video (sending) latency (ms) [lower is better]	1.82	1.00	-82.00%
Video (receiving) jitter (ms) [lower is better]	1.36	N/A	-
Video (sending) jitter (ms) [lower is better]	N/A	N/A	-
Video (receiving) resolution [higher is better]	160x90	160x90	-
Video (sending) resolution [higher is better]	320x180	320x180	-
Video (receiving) frame rate (FPS) [higher is better]	11.00	11.00	0.00%
Video (sending) frame rate (FPS) [higher is better]	13.91	14.00	-0.64%
Screen sharing (sending) bitrate (kbps) [higher is better]	1.00	1.00	0.00%
Screen sharing (sending) latency (ms) [lower is better]	1.54	1.00	-54.00%
Screen sharing (sending) jitter (ms) [lower is better]	N/A	N/A	-
Screen sharing (sending) resolution [higher is better]	1536x824	1536x824	-
Windows 365 Cloud PC VDI environment			
Audio (receiving) bitrate (kbps) [higher is better]	8.91	8.45	5.38%
Audio (sending) bitrate (kbps) [higher is better]	7.73	40.45	-80.90%
Audio (receiving) latency (ms) [lower is better]	1.91	41.64	2080.95%
Audio (sending) latency (ms) [lower is better]	1.91	41.09	2052.38%
Audio (receiving) jitter (ms) [lower is better]	1.73	4.00	131.58%
Audio (sending) jitter (ms) [lower is better]	N/A	2.45	-
Video (receiving) bitrate (kbps) [higher is better]	139.18	224.91	-38.12%
Video (sending) bitrate (kbps) [higher is better]	139.18	224.91	-38.12%
Video (receiving) latency (ms) [lower is better]	1.91	41.64	2080.95%
Video (sending) latency (ms) [lower is better]	1.82	42.82	2255.00%
Video (receiving) jitter (ms) [lower is better]	1.50	2.18	45.45%
Video (sending) jitter (ms) [lower is better]	N/A	1.00	-
Video (receiving) resolution [higher is better]	160x90	160x90	-
Video (sending) resolution [higher is better]	320x180	320x180	-
Video (receiving) frame rate (FPS) [higher is better]	11.00	11.00	0.00%
Video (sending) frame rate (FPS) [higher is better]	13.91	13.91	0.00%
Screen sharing (sending) bitrate (kbps) [higher is better]	1.00	1.00	0.00%
Screen sharing (sending) latency (ms) [lower is better]	1.55	41.82	2,605.88%
Screen sharing (sending) jitter (ms) [lower is better]	1.00	3.27	227.27%
Screen sharing (sending) resolution [higher is better]	1536x824	1534x870	-

	HP Elite mt645 G7 Mobile Thin Client	Dell™ Latitude™ 3420 business laptop	Percent difference
VMware Horizon 8 VDI environment			
Audio (receiving) bitrate (kbps) [higher is better]	10.17	9.00	12.96%
Audio (sending) bitrate (kbps) [higher is better]	6.67	14.09	-52.69%
Audio (receiving) latency (ms) [lower is better]	1.00	1.09	9.09%
Audio (sending) latency (ms) [lower is better]	1.08	1.09	0.70%
Audio (receiving) jitter (ms) [lower is better]	1.00	1.00	0.00%
Audio (sending) jitter (ms) [lower is better]	N/A	N/A	-
Video (receiving) bitrate (kbps) [higher is better]	159.58	1.09	14,528.47%
Video (sending) bitrate (kbps) [higher is better]	159.58	172.45	-7.46%
Video (receiving) latency (ms) [lower is better]	1.00	1.09	9.09%
Video (sending) latency (ms) [lower is better]	2.50	1.09	-56.36%
Video (receiving) jitter (ms) [lower is better]	1.00	1.00	0.00%
Video (sending) jitter (ms) [lower is better]	2.00	N/A	-
Video (receiving) resolution [higher is better]	160x90	160x90	-
Video (sending) resolution [higher is better]	320x180	320x180	-
Video (receiving) frame rate (FPS) [higher is better]	11.00	11.00	0.00%
Video (sending) frame rate (FPS) [higher is better]	14.00	13.91	0.65%
Screen sharing (sending) bitrate (kbps) [higher is better]	1.00	3.45	-71.05%
Screen sharing (sending) latency (ms) [lower is better]	1.36	1.27	-6.67%
Screen sharing (sending) jitter (ms) [lower is better]	N/A	1.00	-
Screen sharing (sending) resolution [higher is better]	1428x732	1428x692	-

For the unified communications testing, we installed VMware Horizon 8 and Windows 365 Cloud PC on each physical client. We accessed Citrix through a web browser, through which we launched our Citrix Workspaces sessions. We followed all VDI platform and Microsoft Teams and Zoom app optimization recommendations before we conducted our 1:1 unified communications end-user experience tests.

Table 2: Results of our benchmark testing. We ran each benchmark test three times and recorded the median results. Higher is better.

	HP Elite mt645 G7 Mobile Thin Client	Dell Latitude 3420 business laptop	Percent difference
Geekbench 5 v5.4.4			
CPU single-core score	1,418	1,370	3.50%
CPU multi-core score	5,840	4,051	44.16%
GPU Compute OpenCL	13,514	12,888	4.86%
PCMark 10 v2.1.2600			
Overall rating	5,713	4,800	19.02%
Essentials overall rating	9,632	9,621	0.11%
Productivity rating	9,421	6,473	45.54%
Digital content creation rating	5,577	4,820	15.71%
PassMark PerformanceTest v10.2			
Overall PassMark rating	4,734.0	3,156.6	49.97%
CPU Mark score	16,622.5	10,276.7	61.75%
2D Graphics Mark score	755.4	329.2	129.47%
3D Graphics Mark score	2,378.6	2,711.4	-12.27%
Memory Mark score	2,109.7	2,669.8	-20.98%
Disk Mark score	11,577.3	25,146.2	-53.96%
PCMark 10 Modern Office battery life v2.1.2600	110 nits	110 nits	
Battery life (hours:min)	11:21	11:02	2.87%
Battery life (minutes per Whr) - normalized	13.4	12.3	8.92%
Performance score	5,875	6,920	-15.10%

Table 3: Raw results of our Linux-based device testing. Higher is better. Unfortunately, we were able to accomplish this on only the Linux-based HP Elite mt645 G7 Mobile Thin Client. The Linux-based Dell Latitude 3420 business laptop we tested did not provide access to Windows 365 or iotop performance metrics.

	HP Elite mt645 G7 Mobile Thin Client	Dell Latitude 3420 business laptop
Geekbench 5 Pro for Linux x86 (64-bit) v5.5.1		
CPU single-core score - Run 1	1,244	N/A-
CPU multi-core score - Run 1	4,684	N/A-
GPU Compute OpenCL - Run 1	N/A-	N/A-
CPU single-core score - Run 2	1,242	N/A-
CPU multi-core score - Run 2	4,689	N/A-
GPU Compute OpenCL score - Run 2	N/A-	N/A-
CPU single-core score - Run 3	1,241	N/A-
CPU multi-core score - Run 3	4,712	N/A-
GPU Compute OpenCL score - Run 3	N/A-	N/A-
Median CPU single-core score	1,242	N/A-
Median CPU multi-core score	4,689	NA/-
Median GPU Compute OpenCL score	N/A-	N/A-

System configuration information

Table 4: Detailed information on the systems we tested.

System configuration information	HP Elite mt645 G7 Mobile Thin Client	HP Elite mt645 G7 Mobile Thin Client	Dell Latitude 3420 business laptop	Dell Latitude 3420 business laptop
Processor				
Vendor	AMD®	AMD	Intel®	Intel
Model number	AMD Ryzen™ 5 5625U	AMD Ryzen™ 3 5425U	Core™ i5-1135G7	Core i3-1115G4
Core frequency (GHz)	2.3-4.3	2.7-4.1	2.4-4.2	3.0-4.1
Number of cores	6	4	4	2
Memory				
Amount (GB)	8 (2 x 4)	8 (2 x 4)	8 (2 x 4)	8 (2 x 4)
Type (MHz)	DDR4 2667	DDR4 2667	DDR4 3200	DDR4 3200
Dual or single channel	Dual	Dual	Dual	Dual
Graphics				
Vendor	AMD	AMD	Intel	Intel
Model number	Radeon™ Graphics	Radeon™ Graphics	Iris Xe® Graphics	UHD Graphics
Storage				
Model	Samsung MZVLQ256HBJD	Samsung MZVLQ256HBJD	KIOXIA KBG50ZNS256G	KIOXIA KBG50ZNS256G
Amount (GB)	256	256	256	256
Type	NVMe®	NVMe	NVMe	NVMe
Connectivity/expansion				
Wireless internet	Realtek RTL8852BE Wi-Fi 6	Realtek RTL8852BE Wi-Fi 6	Intel Wi-Fi 6 AX201	Intel Wi-Fi 6 AX201
Bluetooth	5.3	5.3	5.2	5.2
USB	1 x SuperSpeed USB-C 10Gbps signaling rate (USB Power Delivery, DisplayPort 1.4) 3 x SuperSpeed USB-A 5Gbps signaling rate (charging)	1 x SuperSpeed USB-C 10Gbps signaling rate (USB Power Delivery, DisplayPort 1.4) 3 x SuperSpeed USB-A 5Gbps signaling rate (charging)	1 x USD 3.0 card reader slot 1 x USB 2.0 1 x USB-A 3.2 Gen 1 1 x USB-A 3.2 Gen 1 PowerShare 1 x USB-C 3.2 Gen2 with DisplayPort alt mode/Power Delivery	1 x USD 3.0 card reader slot 1 x USB 2.0 1 x USB-A 3.2 Gen 1 1 x USB-A 3.2 Gen 1 PowerShare 1 x USB-C 3.2 Gen2 with DisplayPort alt mode/Power Delivery
Battery				
Type	Integrated lithium-polymer	Integrated lithium-polymer	Integrated lithium-polymer	Integrated lithium-polymer
Rated capacity (Whr)	51 (3-cell)	51 (3-cell)	54 (4-cell)	54 (4-cell)

System configuration information	HP Elite mt645 G7 Mobile Thin Client	HP Elite mt645 G7 Mobile Thin Client	Dell Latitude 3420 business laptop	Dell Latitude 3420 business laptop
Display				
Size (in.)	14	14	14	14
Resolution	1,920 x 1,080	1,920 x 1,080	1,920 x 1,080	1,920 x 1,080
Touch capability	No	No	No	No
Operating system				
Vendor	Microsoft	HP	Microsoft	Dell Wyse
Name	Windows 10 IoT Enterprise LTSC	ThinPro	Windows 10 IoT Enterprise LTSC	ThinOS 2208
Version	21H2 Build 19044.1706	8.0 SP 2.5	21H2 Build 19044.2728	9.3.2102
BIOS				
BIOS name and version	HP U81 Ver.01.10.01	HP U81 Ver.01.10.01	Dell 1.26.0	Dell 1.26.0
Dimensions				
Height (in.)	0.81	0.81	0.90	0.90
Width (in.)	12.67	12.67	12.83	12.83
Depth (in.)	8.42	8.42	8.9	8.9
System weight (lbs.)	3.0	3.1	3.9	3.9

How we tested

While the HP Elite mt645 G7 Mobile Thin Client we tested shipped with a Windows 10 IoT Enterprise Long Term Servicing Channel (LTSC) 21H2 operating system and an HP ThinPro OS, we had to install both the Dell ThinOS and Windows 10 IoT Enterprise LTSC operating systems on the Dell Latitude 3420 before we started testing. To compare system responsiveness from many angles, we ran PCMark 10 Standard, PassMark PerformanceTest, and Geekbench 5 benchmark tests. We also compared battery life and efficiency by running the PCMark 10 benchmark.

For the unified communications end-user experience comparison, we first set up Citrix Virtual Apps and Desktops 7, VMware Horizon 8, and Windows 365 Cloud PC VDI environments. Then, we compared webcam and audio capabilities on the test devices using Microsoft Teams and Zoom applications.

We also tried to install and run the Geekbench performance benchmark on Linux®-based versions of these mobile devices. Unfortunately, we were able to accomplish this on only the Linux-based HP Elite mt645 G7 Mobile Thin Client. The Dell Linux-based Latitude 3420 business laptop we tested did not provide access to Windows 365 or iotop performance metrics.

Setting up the VDI infrastructure

Configuring the Active Directory VM

We installed and configured a VM to host Active Directory services, DNS, DHCP, NTP, and to be a certificate authority. In addition, we created a golden VM for virtual desktops and applied registry edits to ensure testing executed correctly. All these functions are necessary to run our testing.

Installing Active Directory Domain Services

1. Log into the vSphere client as administrator@vsphere.local.
2. On the infrastructure server, deploy a Windows Server 2022 VM named AD1, and log in as an administrator.
3. Launch Server Manager.
4. Click Manage→Add Roles and Features.
5. At the Before you begin screen, click Next.
6. At the Select installation type screen, leave Role-based or feature-based installation selected, and click Next.
7. At the Server Selection Screen, select the server from the pool, and click Next.
8. At the Select Server Roles screen, select Active Directory Domain Services.
9. When prompted, click Add Features, and click Next.
10. At the Select Features screen, click Next.
11. At the Active Directory Domain Services screen, click Next.
12. At the Confirm installation selections screen, check Restart the destination server automatically if required, and click Install.

Configuring Active Directory and DNS services on AD1

1. After the installation completes, a screen should pop up with configuration options.
2. If a screen does not appear, click the Tasks flag in the upper-right section of Server Manager.
3. Click Promote this server to a Domain Controller.
4. At the Deployment Configuration screen, select Add a new forest.
5. In the Root domain name field, type test.local and click Next.
6. At the Domain Controller Options screen, leave the default values, and enter a password twice.
7. To accept default settings for DNS, NetBIOS, and directory paths, click Next four times.
8. At the Review Options screen, click Next.
9. At the Prerequisites Check dialog, allow the check to complete.
10. If there are no relevant errors, check Restart the destination server automatically if required, and click Install.
11. When the server restarts, log on using test\Administrator and the password you chose in step 6.

Configuring the Windows time service on AD1

To ensure reliable time, we pointed our Active Directory server to an upstream NTP server.

1. Open a command prompt.
2. Type the following:

```
W32tm /config /syncfromflags:manual /manualpeerlist:"<IP address of an NTP server>"
W32tm /config /reliable:yes
W32tm /config /update
W32tm /resync
Net stop w32time
Net start w32time
```


Setting up DHCP services on AD1

1. Open Server Manager.
2. Select Manage, and click Add Roles and Features.
3. Click Next twice.
4. At the Select server roles screen, select DHCP Server.
5. When prompted, click Add Features, and click Next.
6. At the Select Features screen, click Next.
7. Click Next.
8. Review your installation selections, and click Install.
9. Once the installation completes, click Complete DHCP configuration.
10. On the Description page, click Next.
11. On the Authorization page, use the Domain Controller credentials set up previously (TEST\Administrator), and click Commit.
12. On the Summary page, click Close.
13. Click Close on the Add Roles and Features Wizard.
14. In Server Manager, click Tools > DHCP.
15. In the left pane, double-click your server, and click IPv4.
16. In the right pane, under IPv4, click More Actions, and select New Scope.
17. Click Next.
18. Enter a Name and Description for the scope, and click Next.
19. Enter the following values for the IP Address Range:
 - Start IP address: 172.16.10.1
 - End IP address = 172.16.100.254
 - Length = 16
 - Subnet mask = 255.255.0.0
20. Click Next.
21. At the Add Exclusions and Delay page, leave defaults, and click Next.
22. Set the Lease Duration to 30 days, and click Next.
23. At the Configure DHCP Options page, leave Yes selected, and click Next.
24. At the Router (Default Gateway) page, enter the gateway IP address, and click Next.
25. For the parent domain, at the Specify IPv4 DNS Settings screen, type test.local.
26. Type the preferred DNS server and IPv4 address, and click Next.
27. At the WINS Server page, leave the fields empty, and click Next.
28. At the Activate Scope page, leave Yes checked, and click Next.
29. Click Finish.

Installing and configuring SSL Certificate in Microsoft Active Directory on AD1

1. Log onto AD1 as administrator@test.local.
2. Open Server Manager.
3. Select Manage, and click add Roles and Features.
4. When the Add Roles and Features Wizard begins, click Next.
5. Select Role-based or feature-based installation, and click Next.
6. Select AD1.test.local, and click Next.
7. At the server roles menu, expand Active Directory Certificate Services.
8. Select Certification Authority, Certificate Enrollment Web Service, and Certification Authority Web Enrollment.
9. When prompted, click Add Features, and click Next.
10. Leave Select features at defaults, and click Next.
11. At the Active Directory Certificate Services introduction page, click Next.
12. Select Certificate Authority and Certificate Authority Web Enrollment.
13. When prompted, click Add Features, and click Next.
14. Click Next two times, click Install, and close.
15. In Server Manager, click the yellow triangle titled Post-deployment configuration.
16. On the destination server, click Configure Active Directory Certificate Services.
17. Leave credentials as test\administrator, and click Next.
18. Select Certification Authority, Certificate Enrollment Web Service, Certification Authority Web Enrollment, and click Next.

19. Select Enterprise CA, and click Next.
20. Select Root CA, and click Next.
21. Select Create a new private key, and click Next.
22. Select SHA256 with a 2048 Key length, and click Next.
23. Leave the names fields and defaults, and click Next.
24. Change expiration to 10 years, and click Next.
25. Leave Certificate database locations as default, and click Next.
26. Click Configure.
27. When finished configuring, click Close.
28. Open a command prompt, and type `ldp`
29. Click Connection, and connect.
30. For server, type `ad1.test.local`
31. Change the port to 636.
32. Check SSL, and click OK.

Configuring secure LDAP on AD1.test.local on AD1

1. Open administrative tools→Certification Authority.
2. Click test-AD1-CA→Certificate Templates
3. Right-click Manage.
4. Right-click Kerberos Authentication, and select Duplicate Template.
5. Click General.
6. Rename the template and its display name.
7. Click Request Handling.
8. Check the box for Allow private key to be exported, and click OK.
9. Right-click the new template, and rename it `LDAPoverSSL`
10. Return to the Certificates console.
11. In the right pane, right-click New Certificate Template to Issue.
12. Select LDAPoverSSL, and click OK.

Joining VMware vCenter® to Active Directory

1. In the vSphere client, click the Menu drop-down, and select Administration.
2. Under Single Sign On, select Configuration.
3. In the Identity Provider tab, select Active Directory Domain.
4. Select the vCenter, and click Join AD.
5. Enter the AD administrator credentials, and click OK.

Configuring Windows gold image

Creating the baseline Windows 10 VM

1. In vCenter, right-click the host, and select New Virtual Machine...
2. Select Create a New Virtual Machine, click NEXT.
3. Enter a name for the VM, and select the location for the virtual machine. Click NEXT.
4. Select the host for the new VM, click NEXT.
5. Select the datastore for the new VM, click NEXT.
6. Select the compatibility level, "ESXi 7.0 U2 and later". Click NEXT.
7. Select the Guest OS Family and Version: Windows/ Microsoft Windows 10 (64-bit). Click NEXT.
8. Adjust the virtual hardware settings to match:
 - CPU: 2
 - Memory: 4GB, Reserve all guest memory (All locked)
 - New SCSI controller: VMware Paravirtual
 - New Network: <Test network name>, Adapter type: VMXNET 3.
9. Click ADD NEW DEVICE, and select CD/DVD Drive.
10. For the first CD/DVD Drive, browse to the Windows ISO file on the datastore.
11. Delete the New USB Controller.

12. Expand the Video Card drop-down, and select 8 MB of total video memory.
13. Click the VM Options tab, and expand the Advanced drop-down.
14. Click EDIT CONFIGURATION.
15. Click ADD CONFIGURATION PARAMS.
16. In the Name field, enter `devices.hotplug` and set the Value to `false`.
17. Click OK.
18. Click NEXT, then FINISH.
19. Start the VM, then click Launch Remote Console.
20. Select the region settings for Windows 10, click Next.
21. Click Install now.
22. Select Windows 10 Enterprise, click Next.
23. Accept the license agreement, click Next.
24. Click Custom: Install Windows only (advanced).
25. In the vCenter UI, select the VM and click Install VMware Tools..., and select MOUNT.
26. In the VM remote console, click Load driver.
27. Click Browse, and navigate on the VMware Tools drive to `\Program Files\VMware\VMware Tools\Drivers\pvscsi\Win8\amd64`.
28. Click OK.
29. Select the VMware PVSCSI Controller, and click Next.
30. To install on Drive 0, click Next.
31. When presented with the region dialog, press CTRL+SHIFT+F3 to enter Audit mode.

Configuring the baseline VM

1. If not already mounted, in the vCenter console, select the VM, click Install VMware tools..., and select MOUNT.
2. On the VM, click the VMware tools AutoPlay popup, and select Run setup64.exe.
3. On the VMware Tools installer, click Next.
4. Select Custom, click Next.
5. Deselect:
 - Carbon Black Helper
 - Service Discovery
 - Volume Shadow Copy
6. Click Next.
7. Click Install.
8. To install .Net Framework 3.5, open an Administrator command prompt, and enter:

```
DISM /Online /Enable-Feature /FeatureName:NetFx3 /All /LimitAccess /Source:D:\sources\sxs
```

9. Run Windows Update, and reboot the VM.

Installing Zoom

1. Open a browser to: <https://support.zoom.us/hc/en-us/articles/4415057249549-VDI-releases-and-downloads>.
2. Download the current release of Zoom for the appropriate platform.
3. Open and run the installation package on the respective VDI platform gold master image.

Installing Microsoft Teams

1. Open a browser to: <https://learn.microsoft.com/en-us/MicrosoftTeams/teams-for-vdi#deploy-the-teams-desktop-app-to-the-vm>.
2. Download the 64-bit MSI installer package.
3. Install Teams using VDI and per-machine parameters:

```
msiexec /i <path_to_msi> /l*v <install_logfile_name> ALLUSER=1 ALLUSERS=1
```

Installing Horizon Windows agent

1. Download the VMware Horizon 8 agent (64-bit) from <https://customerconnect.vmware.com/>.
2. Run the installer, and click Next.
3. Accept the terms, and click Next.
4. Select IPv4, and click Next.
5. On the Custom Setup page, ensure necessary features are enabled for the test:
 - Core
 - VMware Horizon Instant Clone
 - VMware Audio
 - Real-Time Audio-Video
6. Ensure the following are disabled, and click Next:
 - Scanner Redirection
 - Smartcard Redirection
 - Serial Port Redirection
 - SDO Sensor Redirection
 - VMware Integrated Printing
7. Enable Remote Desktop if prompted, and click Next.
8. Click Install.
9. Click Finish.
10. To reboot, click Yes.

Optimizing the base image using the VMware OS Optimizer Tool

1. Download the latest version of VMware OS Optimizer Tool (OSOT) from <https://customerconnect.vmware.com/>.
2. Run the downloaded file.
3. Click the drop-down template, select the correct version of OS to optimize.
4. Click the Analyze button.
5. Click Common Options.
6. Click Security.
7. Select Disable Firewall, Disable Antivirus, and Disable Security Center, and click OK.
8. Keep the default selections, and click Optimize.
9. At the top, click Finalize.
10. Ensure all boxes are checked, and to begin, at the bottom of the page, click Finalize.
11. Once complete, shut down the VM.
12. In vCenter, right-click the VM, take a snapshot, and label it as `Gold Baseline`

Installing Citrix Windows agent

1. On the Citrix gold VM, open the Virtual Apps and Desktops installation ISO.
2. Run the downloaded file, select Create a master MCS image, and click Next.
3. On the Core Components page, select Citrix Workspace App, and click Next.
4. On the Additional Components page, click Next.
5. On the Delivery Controller page, select Do it Manually, enter the controller address, click Test Connection, click Add, and click Next.
6. On the Features page, enable Use Real-Time Audio Transport for audio, and click Next.
7. On the Firewall page, click Next.
8. On the Summary page, click Install.
9. Uncheck Collect diagnostic information, and click Next.
10. Ensure Restart machine is checked, and click Finish.

Configuring Citrix Windows VM

1. Extract CitrixOptimizerTool.zip to desktop.
2. Run CitrixOptimizerTool.exe.
3. Click the default selection, Windows 10 version 20H2, 21H1, 21H2, 22H2 (2009) from Citrix.
4. Click Analyze.
5. Click Optimize.
6. Once the process is complete, click Done. Note that if Windows Update has not been disabled by AD GPO, it will show as Failed.
7. Close the application.
8. Shut down the VM, take a snapshot, and label it for VDI use.

Configuring the VMware Horizon 8 connection server

1. On the infrastructure server, deploy a Windows Server 2022 VM named "view" with 8 vCPUs and 16 GB of memory, and log in as an administrator.
2. Join the VM to the test.local domain, reboot, and log back in as a domain administrator.
3. Browse to VMware View installation media, and run the installation executable file.
4. At the Welcome screen, click Next.
5. Agree to the End User License Agreement, and click Next.
6. Keep the default installation directory, and click Next.
7. Select View Standard Server, and click Next.
8. At the Data Recovery screen, enter a backup password, and click Next.
9. Allow View Server to configure the Windows firewall automatically, and click Next.
10. Authorize the domain administrator to administer View, and click Next.
11. Choose whether or not to participate in the customer experience improvement program, and click Next.
12. To finish installing View Connection Server, complete the installation wizard.
13. Click Finish.
14. Reboot server.

Configuring the VMWare Horizon 8 connection server on the View VM

1. Open a Web browser, and navigate to <http://<View connection FQDN>/admin>.
2. Log in as administrator.
3. Under Settings->Product Licensing and Usage, click Edit License.
4. Enter a valid license serial number, and click OK.
5. Under Settings->Servers, in the vCenter Servers tab, click Add.
6. Enter vCenter server credentials, and verify the following settings:
 - Max concurrent vCenter provisioning operations: 20
 - Max concurrent power operations: 50
 - Max concurrent Instant Clone Engine provisioning operations: 20
7. Click Next.
8. Enter full domain name and user credentials. Do not use Reclaim VM disk space or Enable View Storage Accelerator.
9. At the ready to complete screen, click Finish.
10. Open Horizon 8 View Administrator.
11. Log in as an administrator.
12. Select Settings > Domains.
13. Under Instant Clone Engine Domain Accounts, click Add.
14. Enter the Domain Name, Username, and Password for the domain administrator.
15. Click OK.

Deploying virtual desktops using VMware Horizon 8 connection server

1. Click Inventory → Desktops, and click Add.
2. Leave Automated Desktop Pool selected, and click Next.
3. Leave Instant Clone selected, and click Next.
4. Leave Dedicated and Automatic Assignment selected, and click Next.
5. Select Use VMware Virtual SAN, and click Next.
6. Enter a pool ID and Display Name, and click Next.
7. Enter a naming pattern and maximum number of machines, and click Next.
8. Browse to the Golden Image in vCenter, and click Submit.
9. Browse to the Snapshot, and click Submit.
10. Browse to the VM folder Location, and click Submit.
11. Browse to the Cluster, and click Submit.
12. Browse to the Resource Pool, and click Submit.
13. Browse to the Datastore, click Submit, and click Next.
14. On the Desktop Pool Settings page, click Next.
15. On the Remote Display Protocol page, click Next.
16. On the Guest Customization page, browse to the AD Container, click Submit, and click Next.
17. On the Ready to Complete page, click Submit.
18. Click the Entitlements drop-down, and click Add Entitlements.
19. On the Add Entitlements page, click Add, enter the group name, click Find, check the box next to the group, and click OK twice.

Adding machines and users to existing pools

1. In the Desktops panel, click the pool name, and click Edit.
2. Select the Provisioning Settings tab, and change the Maximum Machines to 50. Click OK.

Configuring Citrix Virtual Apps and Desktops

Installing Citrix Virtual Apps and Desktops (VAAD)

1. On a Windows Server 2022 VM, open the Virtual Apps and Desktops ISO, and next to Virtual Apps and Desktops, click Start.
2. Select Delivery Controller.
3. Accept the EULA, and click Next.
4. To install all available components, click Next.
5. Enable all Features, and click Next.
6. Leave Automatically checked, and click Next.
7. Review the Summary, and click Install.
8. On the Diagnostics page, choose whether to collect diagnostic information, and click Next.
9. Click Finish, and reboot if prompted.
10. Open the VAAD ISO, and run the AutoSelect application.
11. Select Citrix StoreFront.
12. Accept the terms of use, and click Next.
13. On the Review prerequisites screen, click Next.
14. Click Install.
15. Open Citrix Studio, and in the Site Setup steps screen, click Deliver applications and desktops to your users.
16. Select A fully configured production-ready Site (recommended for new users).
17. Enter a name for the site. Click Next.
18. Select Create and set up Databases from Studio. Click Next.
19. Confirm the license server address is set to localhost:27000. Click Connect.
20. Browse for license file, and select the license issued for testing.
21. Select Citrix Virtual Apps and Desktops Premium - Concurrent. Click Next.
22. On the Connection page, select VMware vSphere.
23. Enter the connection address, username, password, and name for the connection.
24. Select Citrix provisioning tools. Click Next.
25. If using self-signed certificates, click Trust certificate, and click OK.
26. Click Browse, select the cluster for the virtual desktop deployment, and click OK.
27. Select Use storage shared by hypervisors. Click Next.
28. Select the storage to use. Click Next.
29. Name the network resources to use, select the test network, and click Next.
30. Leave App-V Publishing unselected. Click Next.
31. Click Finish.

Deploying VAAD virtual desktops

Creating a machine catalog

1. On the Site Setup steps screen, click option 2, Set up machines for desktops and applications or remote PC access.
2. On the Introduction page, click Next.
3. On the Operating System page, select Single-session OS, and click Next.
4. On the Machine Management page, select Machines that are power managed.
5. Select Deploy machines using Citrix Machine Creation Services (MCS). Click Next.
6. Under Desktop Experience, select I want users to connect to the same (static) desktop each time they log on.
7. Select No, discard all changes and clear virtual desktops when the user logs off. Click Next.
8. On the Master Image page, select the master image and snapshot, and set the minimum functional level to 2206 (or newer). Click Next.
9. On the Virtual Machines page, for the number of virtual machines, enter 10 .
10. For the Total memory (MB) on each machine, enter 4096
11. On the Computer accounts page, select the Active Directory location for the new computer accounts, and a naming schema. Click Next.
12. On the Summary page, enter the Machine Catalog name, and click Finish.

Creating a delivery group

1. In the Common Tasks pane at the root of Citrix Studio, select Create a new Delivery Group.
2. On the Introduction page, click Next.
3. On the Machines page, change the number of machines to 10, and click Next.
4. On the Delivery Type page, select Desktops. Click Next.
5. On the Users page, select Restrict use of this Delivery Group to the following users, and select the allowed user group. Click Next.
6. On the Desktop Assignment Rules page, click Add, enter a Display name, and click OK. Click Finish, and click Next.
7. On the Summary page, enter the Delivery Group name, and click Finish.
8. Click the Delivery Groups item in the navigation pane.
9. Right-click the new delivery group, select Edit delivery group.
10. Select the Machine allocation page, and click Import list. Browse to a previously generated list, click Open, click Apply, and click OK.

Adding a StoreFront server

1. In the navigation pane, select StoreFront.
2. In the Actions pane, click Add StoreFront Server.
3. Enter StoreFront server name, description, and URL.

Measuring unified communications end-user experiences

For the unified communications testing, we installed VMware Horizon 8 and Windows 365 Cloud PC on each physical client. We accessed Citrix through a web browser, through which we launched our Citrix Workspaces sessions. We followed all VDI platform and Microsoft Teams and Zoom app optimization recommendations before we conducted our 1:1 unified communications end-user experience tests..

Installing VMware Horizon 8

1. Navigate to https://customerconnect.vmware.com/en/downloads/info/slug/desktop_end_user_computing/vmware_horizon_clients/horizon_8 and on the appropriate version of the client, click Go to Downloads.
2. Click Download now.
3. Once the download finishes, run the installer.
4. Click Agree and install.
5. Once the install finishes, click Finish.
6. Click Restart now.

Configuring the VMware Horizon 8 client

1. To launch, double-click Horizon client.
2. Click Settings.
3. Click Security.
4. Click Certificate policy, change to Do not verify sever identity certificate, and click Exit settings.
5. Click Add Server.
6. Under Connect Name, enter the Horizon client server URL, and click Connect.
7. When prompted, enter VDI credentials, and click Connect.

Installing Windows Remote Desktop Connection (RDC)

1. Navigate to <https://go.microsoft.com/fwlink/?linkid=2139369>, and download the 64-bit client.
2. Once the download finishes, run the installer.
3. Click Next.
4. Click Accept terms, and click Next.
5. Click Install.
6. Click Finish.

Configuring Windows RDC

1. Navigate to <https://windows365.microsoft.com/#/>, and sign in.
2. Before proceeding, navigate to admin.microsoft.com.
3. Click Users.
4. Search for the User who owns the Client.
5. Click that User.
6. Click Devices.
7. Scroll down the Cloud PC, click the 3 dots, and click Change Account Type.
8. Click Local Administrator, and wait for the change to finish.
9. To force the change to apply, click Restart.
10. Download Windows 64 Bit Remote Desktop Client from Microsoft.
11. On Welcome Wizard, click Next.
12. To accept terms, check, and click Next.
13. Leave Install Just for you (Admin) ticked, and click Install.
14. Once the install finishes, click Finish.
15. In the Remote Desktop Client, click Subscribe, and log into the Windows 365 account.

Configuring Zoom VDI instances

1. Under New meeting, click the drop-down menu.
2. Click Use My Personal Meeting ID (PMI).
3. To access settings, click the cog, and make the following selections:
 - Under General, enable Full screen automatically for meetings in Zoom.
 - Under Audio, enable Automatically join audio by computer when joining.
 - Under Share screen, enable Side-by-side mode.

Testing Zoom on Windows laptops in a Citrix Virtual Apps and Desktops 7 VDI environment

1. Boot the sender laptop.
2. Navigate to: <https://citrixvaad.bulosan.local/Citrix/CitrixVDIWeb/>.
3. Log in with proper credentials.
4. Go to Preferences, and set Camera/Audio to automatically use.
5. Navigate to Desktops.
6. Select Connect.
7. Once connected, start Zoom.
8. Once Zoom starts, launch Microsoft Edge.
9. Navigate to the test PowerPoint spreadsheet.
10. Open the test document.
11. Switch to Zoom, and click New Meeting.
12. On the receiver laptop, click Join meeting.
13. Enable both video cameras.
14. To simulate a conversation, play audio that both Zoom clients can hear. Run audio for the duration of the call.
15. To load the test document, switch to the PowerPoint screen, and open the test document.
16. To share the document, switch back to Zoom, click Screen Share, and click the test document.
17. On both laptops, begin the perfmon data logging.
18. On the VDI client, begin the perfmon data logging.
19. To begin the PowerPoint slideshow, click Present.
20. After 10 minutes, stop both perfmons.
21. End the Zoom call.

22. Once the Zoom call has ended, navigate to the Zoom admin dashboard, click Meetings, and click Past meetings.
23. Click the test Meeting ID, and click the VDI host's username.
24. From that user's statistic page, click Export Details to CSV, and click Go to Downloads Page.
25. From the Downloads page, check the box for the CSV just generated, and click download.
26. Disconnect from the VDI Client
27. Record the QoS results.
28. Restart the sender laptop, and complete steps 2 through 27 two more times.

Testing Zoom on Windows laptops in a VMware Horizon 8 VDI environment

1. Boot the sender laptop.
2. To open the client, click Horizon Client.
3. To connect, click the saved server.
4. Enter the password, and click Login.
5. To connect, click the desired VDI.
6. Once connected, start Zoom.
7. Once Zoom starts, launch Microsoft Edge.
8. Navigate to the test PowerPoint spreadsheet.
9. Open the test document.
10. Switch to Zoom, and click New Meeting.
11. On the receiver laptop, click Join meeting.
12. Enable both video cameras.
13. To simulate a conversation, play audio that both Zoom clients can hear. Run audio for the duration of the call.
14. To load the test document, switch to the PowerPoint screen, and open the test document.
15. To share the document, switch back to Zoom, click Screen Share, and click the test document.
16. On both laptops, begin the perfmon data logging.
17. On the VDI client, begin the perfmon data logging.
18. To begin the PowerPoint slideshow, click Present.
19. After 10 minutes, stop both perfmons.
20. End the Zoom call.
21. Once the Zoom call has ended, navigate to the Zoom admin dashboard, click Meetings, and click Past meetings.
22. Click the test Meeting ID, and click the VDI host's username.
23. From that user's statistic page, click Export Details to CSV, and click Go to Downloads Page.
24. From the Downloads page, check the box for the CSV just generated, and click download.
25. Disconnect from the VDI Client
26. Record the QoS results.
27. Restart the sender laptop, and complete steps 2 through 26 two more times.

Testing Zoom on Windows laptops in a Windows 365 Cloud PC VDI environment

1. Boot the sender laptop.
2. To open the client, click Windows RDC
3. Enter Windows 365 credentials, and click connect.
4. Click the correct VDI instance.
5. To connect, enter credentials again, and click OK.
6. Once connected, start Zoom.
7. Once Zoom starts, launch Microsoft Edge.
8. Navigate to the test PowerPoint spreadsheet.
9. Open the test document.
10. Switch to Zoom, and click New Meeting.
11. On the receiver laptop, click Join meeting.
12. Enable both video cameras.
13. To simulate a conversation, play audio that both Zoom clients can hear. Run audio for the duration of the call.
14. To load the test document, switch to the PowerPoint screen, and open the test document.
15. To share the document, switch back to Zoom, click Screen Share, and click the test document.
16. On both laptops, begin the perfmon data logging.
17. On the VDI client, begin the perfmon data logging.
18. To begin the PowerPoint slideshow, click Present.

19. After 10 minutes, stop both perfmons.
20. End the Zoom call.
21. Once the Zoom call has ended, navigate to the Zoom admin dashboard, click Meetings, and click Past meetings.
22. Click the test Meeting ID, and click the VDI host's username.
23. From that User's statistic page, click Export Details to CSV, and click Go to Downloads Page.
24. From the Downloads page, check the box for the CSV just generated, and click download.
25. Disconnect from the VDI Client
26. Record the QoS results.
27. Restart the sender laptop, and complete steps 2 through 26 two more times.

Testing Microsoft Teams on Windows laptops in a Citrix Virtual Apps and Desktops 7 VDI environment

1. Boot the sender laptop.
2. Navigate to: <https://citrixvaad.bulosan.local/Citrix/CitrixVDIWeb/>.
3. Log in with proper credentials
4. Go to Preferences, set Camera/Audio to automatically use.
5. Navigate to Desktops.
6. Select Connect.
7. Once connected, start Microsoft Teams.
8. Once Teams starts, launch Microsoft Edge.
9. Navigate to the test PowerPoint spreadsheet.
10. Switch to Teams, click Calls, and click the Start Video Call icon.
11. On the receiver laptop, click Accept video call.
12. Enable both video cameras.
13. To simulate a conversation, play audio that both Teams clients can hear. Run audio for the duration of the call.
14. To load the test document, switch to the PowerPoint screen, and open the test document.
15. To share the document, switch back to Teams, click Screen Share, and click the test document.
16. On both laptops, begin the perfmon data logging.
17. On the VDI client, begin the perfmon data logging.
18. To begin the PowerPoint slideshow, click Present.
19. Switch back to Teams, click More Actions, click Settings, and click Call Health.
20. From the right-hand menu, take screenshots of audio, network, and video data every 60 seconds.
21. After 10 minutes, stop both perfmons.
22. End the Microsoft Teams call.
23. Disconnect from the VDI client.
24. Restart the sender laptop, and complete steps 2 through 23 two more times.

Testing Microsoft Teams on Windows laptops in a VMware Horizon 8 VDI environment

1. Boot the sender laptop.
2. To open the client, click the Horizon Client.
3. To connect, click the saved server.
4. Enter the password, and click Login.
5. Click the desired VDI to connect.
6. Once connected, start Microsoft Teams.
7. Once Teams starts, launch Microsoft Edge.
8. Navigate to the test PowerPoint spreadsheet.
9. Switch to Teams, click Calls, and click the Start Video Call icon.
10. On the receiver laptop, click Accept video call.
11. Enable both video cameras.
12. To simulate a conversation, play audio that both Teams clients can hear. Run audio for the duration of the call.
13. To load the test document, switch to the PowerPoint screen, and open the test document.
14. To share the document, switch back to Teams, click Screen Share, and click the test document.
15. On both laptops, begin the perfmon data logging.
16. On the VDI client, begin the perfmon data logging.
17. To begin the PowerPoint slideshow, click Present.
18. Switch back to Teams, click More Actions, click Settings, and click Call Health.

19. From the right-hand menu, take screenshots of audio, network, and video data every 60 seconds.
20. After 10 minutes, stop both perfmons.
21. End the Microsoft Teams call.
22. Disconnect from the VDI client.
23. Restart the sender laptop and complete steps 2 through 22 two more times.

Testing Microsoft Teams on Windows laptops in a Windows 365 Cloud PC VDI environment

1. Boot the sender laptop.
2. To open the client, click the Remote Desktop Client.
3. Enter Windows 365 credentials, and click connect.
4. Click the correct VDI instance.
5. To connect, enter credentials, and click OK.
6. To connect, click the desired VDI.
7. Once connected, start Microsoft Teams.
8. Once Teams starts, launch Microsoft Edge.
9. Navigate to the test PowerPoint spreadsheet.
10. Switch to Teams, click Calls, and click the Start Video Call icon.
11. On the receiver laptop, click Accept video call.
12. Enable both video cameras.
13. To simulate a conversation, play audio that both Teams clients can hear. Run audio for the duration of the call.
14. To load the test document, switch to the PowerPoint screen, and open the test document.
15. To share the document, switch back to Teams, click Screen Share, and click the test document.
16. On both laptops, begin the perfmon data logging.
17. On the VDI client, begin the perfmon data logging.
18. To begin the PowerPoint slideshow, click Present.
19. Switch back to Teams, click More Actions, click Settings, and click Call Health.
20. From the right-hand menu, take screenshots of audio, network, and video data every 60 seconds.
21. After 10 minutes, stop both perfmons.
22. End the Microsoft Teams call.
23. Disconnect from the VDI client.
24. Restart the sender laptop and complete steps 2 through 23 two more times.

Testing Zoom on Linux laptops in a Citrix Virtual Apps and Desktops 7 VDI environment

Configuring Linux-based HP Mobile Thin Clients running ThinPro OS

1. Boot the sender laptop.
2. Click Browser.
3. Navigate to: <https://citrixvaad.bulosan.local/Citrix/CitrixVDIWeb/>.
4. Log in with proper credentials.
5. Go to Preferences, and set Camera/Audio to automatically use.
6. Navigate to Desktops.
7. Select Connect.
8. Once connected, start Zoom.
9. Once Zoom starts, launch Microsoft Edge.
10. Navigate to the test PowerPoint spreadsheet.
11. Open the test document.
12. Switch to Zoom, and click New Meeting.
13. On the receiver laptop, click join meeting.
14. Enable both video cameras.
15. To simulate a conversation, play audio that both Zoom clients can hear. Run audio for the duration of the call.
16. To load the test document, switch to the PowerPoint screen, and open the test document.
17. To share the document, switch back to Zoom, click Screen Share, and click the test document.
18. On the sender laptop, begin the top data logging.
19. On the VDI client, begin the perfmon data logging.
20. To begin the PowerPoint slideshow, click Present.
21. After 10 minutes, stop both Linux Top and Windows perfmon data logging.

22. End the Zoom call.
23. Once the Zoom Call has ended, navigate to the Zoom admin dashboard, click Meetings, and click Past meetings.
24. Click the test Meeting ID, and click the VDI host's username.
25. From that user's statistic page, click Export Details to CSV, and click Go to Downloads Page.
26. From the Downloads page, check the box for the CSV just generated, and click Download.
27. Disconnect from the VDI client.
28. Record the QoS results.
29. Restart the sender laptop and complete steps 2 through 28 two more times.

Configuring Linux-based Dell laptops running ThinOS

1. Boot the sender laptop.
2. Click Settings, and click Remote Connections.
3. For Select Broker Type, select Citrix Virtual Apps and Desktops.
4. Enter the URL for the Broker Server.
5. Leave all other settings as they appear, and click OK.
6. Log in with proper credentials, add the domain name of the Citrix VDI, and click Login.
7. Once connected, start Zoom.
8. Once Zoom starts, launch Microsoft Edge.
9. Navigate to the test PowerPoint spreadsheet.
10. Open the test document.
11. Switch to Zoom, and click New Meeting.
12. On the receiver laptop, click Join meeting.
13. Enable both video cameras.
14. To simulate a conversation, play audio that both Zoom clients can hear. Run audio for the duration of the call.
15. To load the test document, switch to the PowerPoint screen, and open the test document.
16. To share the document, switch back to Zoom, click Screen Share, and click the test document.
17. On the sender laptop, begin the top data logging.
18. On the VDI client, begin the perfmon data logging.
19. To begin the PowerPoint slideshow, click Present.
20. After 10 minutes, stop both Linux Top and Windows perfmon data logging.
21. End the Zoom call.
22. Once the Zoom Call has ended, navigate to the Zoom admin dashboard, click Meetings, and click Past meetings.
23. Click the test Meeting ID, and click the VDI host's username.
24. From that user's statistic page, click Export Details to CSV, and click Go to Downloads Page.
25. From the Downloads page, check the box for the CSV just generated, and click Download.
26. Disconnect from the VDI client.
27. Record the QoS results.
28. Restart the sender laptop and complete steps 2 through 27 two more times.

Testing Zoom on Linux laptops in a Horizon 8 VDI environment

Configuring Linux-based HP Mobile Thin Clients running ThinPro OS

1. Boot the sender laptop.
2. Double-click Horizon Client.
3. Enter Domain, username, and password, and click Connect.
4. Go to Settings, Remote Connections, Security, and set the certificate policy to Do not verify sever identity certificate.
5. To connect, click the correct VDI.
6. Once connected, start Zoom.
7. Once Zoom starts, launch Microsoft Edge.
8. Navigate to the test PowerPoint spreadsheet.
9. Open the test document.
10. Switch to Zoom, and click New Meeting.
11. On the receiver laptop, click Join meeting.
12. Enable both video cameras.
13. To simulate a conversation, play audio that both Zoom clients can hear. Run audio for the duration of the call.
14. To load the test document, switch to the PowerPoint screen, and open the test document.

15. To share the document, switch back to Zoom, click Screen Share, and click the test document.
16. On the sender laptop, begin the top data logging.
17. On the VDI client, begin the perfmon data logging.
18. To begin the PowerPoint slideshow, click Present.
19. After 10 minutes, stop both Linux Top and Windows perfmon data logging.
20. End the Zoom call.
21. Once the Zoom Call has ended, navigate to the Zoom admin dashboard, click Meetings, and click Past meetings.
22. Click the test Meeting ID, and click the VDI host's username.
23. From that User's statistic page, click Export Details to CSV, and click Go to Downloads Page.
24. From the Downloads page, check the box for the CSV just generated, and click Download.
25. Disconnect from the VDI client.
26. Record the QoS results.
27. Restart the sender laptop and complete steps 2 through 26 two more times.

Configuring Linux-based Dell laptops running ThinOS

1. Power on and log into the physical machine.
2. Click Settings, and click Remote Connections.
3. For Select Broker Type, select VMware Horizon.
4. Enter the URL for the Broker Server.
5. For Security Mode, select Low (Do not verify identify certificates).
6. Leave all other settings as they appear, and click OK.
7. Log in with proper credentials and the domain name of the Citrix VDI, and click Login.
8. Once connected, start Zoom.
9. Once Zoom starts, launch Microsoft Edge.
10. Navigate to the test PowerPoint spreadsheet.
11. Open the test document.
12. Switch to Zoom, and click New Meeting.
13. On the receiving laptop, click Join meeting to join the meeting by Personal Meeting ID.
14. Enable both video cameras.
15. To simulate a conversation, play audio that both Zoom clients can hear. Run audio for the duration of the call.
16. To load the test document, switch to the PowerPoint screen, and open the test document.
17. To share the document, switch back to Zoom, click Screen Share, and click the test document.
18. On the VDI client, begin the perfmon data logging.
19. Click Present to begin the slide show.
20. To begin the PowerPoint slideshow, click Present.
21. After 10 minutes, stop Windows Perfmon data logging.
22. End the Zoom call.
23. Once the Zoom Call has ended, navigate to the Zoom Admin Dashboard, click Meetings, and click Past Meetings.
24. Click the test Meeting ID, and click the VDI host's username.
25. From that user's statistic page, click Export Details to CSV, and click Go to Downloads Page.
26. From the Downloads page, check the box for the CSV just generated, and click download.
27. Disconnect from the VDI client.
28. Restart the physical machine.

Testing Zoom on Linux laptops in a Windows 365 Cloud PC VDI environment

Note: We were able to access Windows 365 performance metrics on the HP Linux-based laptop through a browser. The Dell laptop we tested did not have a browser or terminal, so we did not have access to Windows 365 or iotop performance metrics.

Configuring Linux-based HP Mobile Thin Clients running ThinPro OS

1. Boot the sender laptop.
2. Navigate to windows365.microsoft.com.
3. Enter Windows 365 credentials, and log in.
4. Click the correct VDI instance, and click Connect.
5. To connect, enter credentials, click OK, and click the desired VDI.
6. Once connected, start Zoom.
7. Once Zoom starts, launch Microsoft Edge.
8. Navigate to the test PowerPoint spreadsheet.
9. Open the test document.
10. Switch to Zoom, and click New Meeting.
11. On the receiver laptop, click join meeting.
12. Enable both video cameras.
13. To simulate a conversation, play audio that both Zoom clients can hear. Run audio for the duration of the call.
14. To load the test document, switch to the PowerPoint screen, and open the test document.
15. To share the document, switch back to Zoom, click Screen Share, and click the test document.
16. On the sender laptop, begin the top data logging.
17. On the VDI client, begin the perfmon data logging.
18. To begin the PowerPoint slideshow, click Present.
19. After 10 minutes, stop both Linux Top and Windows Perfmon data logging.
20. End the Zoom call.
21. Once the Zoom Call has ended, navigate to the Zoom admin dashboard, click Meetings, and click Past meetings.
22. Click the test Meeting ID, and click the VDI host's username.
23. From that user's statistic page, click Export Details to CSV, and click Go to Downloads Page.
24. From the Downloads page, check the box for the CSV just generated, and click download.
25. Disconnect from the VDI Client
26. Record the QoS results.
27. Restart the sender laptop and complete steps 2 through 26 two more times.

Measuring system performance

Testing with PCMark 10 Standard

Setting up the test

1. Purchase and download the PCMark 10 benchmark from <https://benchmarks.ul.com/pcmark10>.
2. Install PCMark 10.
3. Launch PCMark 10.
4. Select Business Edition, and input the license key.
5. Close PCMark 10.

Running the test

1. Boot the system.
2. Select Windows Start.
3. Type cmd and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundl132.exe advapi32.dll,ProcessIdleTasks`. Do not interact with the system until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Launch PCMark 10.
7. While on the Home tab, to begin the test, click Run.
8. When the test completes, record the results, and shut down the system.
9. Repeat steps 1 through 8 twice more, and record the median results.

Testing with PassMark PerformanceTest

Setting up the test

1. Install PassMark PerformanceTest.
2. Download PassMark PerformanceTest from <https://www.passmark.com/products/performancectest/download.php>.
3. To begin the installation, press Install.
4. Select Accept to accept the license agreement, and press Next.
5. After the installation is complete, deselect Launch Performance Test, and press Finish.

Running the test

1. To launch PassMark PerformanceTest, press the PassMark PerformanceTest icon.
2. To start the benchmark, press Run Benchmark.
3. When the test completes, record the results.
4. Repeat steps 1 through 3 two more times, and report the median of the three runs.

Testing with Geekbench 5

Setting up the test (Windows & Thin OS Linux)

1. Download and install Geekbench 5 from <https://www.geekbench.com/download/>.

Running the test (Windows & Thin OS Linux)

1. Launch Geekbench.
2. Click Run CPU Benchmark.
3. Record the result.
4. Wait 5 minutes before the GPU OpenCL Compute Benchmark.
5. Record the result.
6. Wait 5 minutes before rerunning the CPU Benchmark.
7. Repeat steps 2 through 6 twice more, and report the median results.

Measuring battery life using the PCMark 10 Modern Office benchmark

Note: Performing this test requires the following items:

- X-Rite - i1Display Plus colorimeter

Setting up the modern office test

1. Purchase and download the PCMark 10 benchmark from <https://benchmarks.ul.com/pcmark10>.
2. Install PCMark 10.
3. Launch PCMark 10.
4. Select Business Edition, input the license key, and select Continue.
5. Click Update.
6. When the update is complete, close PCMark 10.
7. Verify that the display will remain on, and disable power saving options.
8. Right-click the desktop, and select Display settings.
9. Next to Change brightness automatically when lighting changes, uncheck the box.
10. Select Battery, and make the following selections:
 - Under Turn battery saver on automatically drop-down menu, verify that the default 20 percent is set.
 - Next to Lower screen brightness while in battery saver, uncheck the box.
11. Select Power & sleep, and make the following selections:
 - Under the Screen heading, change both the On battery power, turn off option and the When plugged in, turn off after option to Never.
 - Under the Sleep heading, change both the On battery power, turn off option and the When plugged in, turn off after option to Never.
12. Click Additional Power Settings.
13. Click Change Plan settings.
14. Click Change Advanced Power Settings.

15. Expand the Battery field, and make the following selections:
 - Under Critical Battery Notifications, choose Off.
 - Under Low Battery Notifications, choose Off.
16. To bring up a pure white screen, go to C:\Program Files\UL\PCMark 10\Battery Life Calibration Tools, and open the pure_white_page.html file.
17. Unplug the systems.
18. Allow the screens to warm up for 30 minutes.
19. Use the X-Rite - i1Display Plus colorimeter to adjust each screen to a brightness as close as possible to the PCMark 10 guideline of 110 cd/m2:
 - a. Right-click the desktop, and select Display settings.
 - b. Adjust the slider bar until the luminance meter reads 110 nits.

Running the Modern Office benchmark

1. Verify that the system's battery is fully charged.
2. Boot the system.
3. Select Windows Start.
4. Type cmd, and press Ctrl+Shift+Enter.
5. Type `cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`. Do not interact with the system until the command completes.
6. After the command completes, wait 5 minutes before running the test.
7. Launch PCMark 10.
8. Select More Tests, and select the Battery tab.
9. Select the Modern Office battery profile.
10. Unplug the system under test.
11. Click Run.
12. When the system powers off, reconnect the power, and boot the system.
13. Record the result.
14. Repeat steps 1 through 13 two more times.

Read the report at <https://facts.pt/TJjq4se> ▶

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