

SELECT THE RIGHT THIN CLIENT TO IMPROVE USER EXPERIENCE

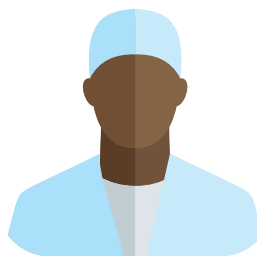
Delivering applications virtually, either as published applications or as part of a virtual desktop, is common in healthcare. Healthcare organizations use virtualization to keep patient data secure in the data center while providing consistent access to an electronic-medical-record (EMR) platform across multiple locations and devices.

Organizations that deploy virtualization to access apps or desktops may use thin clients at desks or shared workstations. There is a wide range of thin clients available, and it may not always be clear how to choose the right thin client for a particular user profile. Healthcare IT departments will want to carefully consider thin clients' abilities to support increasingly advanced workloads, such as video conferencing, voice transcription, and picture archiving and communication system (PACS) access. A best practice before deploying thin clients is to evaluate specific user workflow and application requirements and match selected thin clients to users' needs.

In order to assess how the computational power of processors affects the productivity of healthcare users filling different roles, Prowess tested a number of devices with virtualized and locally installed applications. Our testing demonstrates that a variety of thin-client devices—with processors of differing computational power—all provide a baseline of functionality. However, in order to maximize user productivity for users requiring advanced workloads, thin-client devices with more powerful processors are the right choice.



Faster processors benefit workers who rely on a mix of virtual and locally installed applications.



All devices tested worked well for providing virtualized access to one or a few applications.



Even for virtualized application access, more powerful processors enable faster access and increase overall productivity.

When One Size Doesn't Fit All

Modern healthcare is complex, and the impacts of digital transformation are ever present. Digitization has fundamentally changed healthcare workflows and created a greater reliance on computing devices and software applications, such as EMRs. To bridge digital transformation with legacy systems and infrastructure, healthcare IT teams deploy a range of application-delivery methods. An increasing number of organizations are adopting new tools to enable effective collaboration. At the same time, organizations must continue to support a smaller set of workers who need access to specialized applications that might or might not yet be available as virtualized applications.

In this new digital environment, health workers need access to critical applications anytime, anywhere. Unlike the gowns patients wear for exams or in-patient stays, these workers can't simply be issued the same device. Instead, the varying needs of healthcare workers require IT strike a balance between supporting current and future workloads while managing cost and resource constraints. Considerations such as security, manageability, and support costs all factor into total cost of ownership (TCO) calculations and need to be considered when creating a device strategy.

Thin clients are one of the types of devices that healthcare organizations include in their enterprise device strategies. Thin clients are often found in organizations that have adopted a virtualized model for deploying key applications, such as an EMR solution, or full desktops. Because of the popularity of thin clients in healthcare, Prowess Consulting set out to test which thin clients work best for different users' needs. To do this, we created a series of simulated healthcare workloads ranging from basic EMR access to complex multitasking workloads to evaluate how different thin clients powered by 5th and 6th generation Intel® processors perform. Our goal was to show how a healthcare IT department can improve the user experience for thin-client users by choosing the right device powered by the right processor for the tasks at hand.

User Roles Examined

For our test purposes, we grouped user roles into two categories:

- **Task workers** primarily need access to virtualized applications and collaboration tools; these workers include nurses, nurse assistants, and front-office staff.
- **Knowledge workers** need access to specialized applications and content-creation tools in addition to virtualized applications and collaboration tools; these workers include doctors, technicians, administrators, and IT staff.

Devices Tested

We classified each of the tested devices as either a task-worker or knowledge-worker device. Because task workers generally rely on fewer applications, we selected devices with entry-level processors to approximate what might be commonly deployed. More powerful processors were chosen for knowledge-worker devices to reflect the needs of more intensive workloads, including content creation, collaboration, and dictation. Table 1 shows a full list of the devices we tested and how they were divided between task-workers and knowledge-workers.

Our testing uses common usage models to provide a baseline. Our approach is not intended to replace the need for a thorough analysis of your own users' needs. For example, if collaboration with video conferencing is an organizational standard practice, you might want to consider higher power processors for all workers.

Table 1. Task-worker and knowledge-worker devices tested

User	Device	Processor
Task worker	Intel® Compute Stick	Intel Atom® x5-Z8300 processor
	Dell™ Wyse™ 3030 LT	Intel® Celeron® processor N2807
	Lenovo® ThinkCentre® M700 Tiny	Intel® Core™ i3-6100T processor
Knowledge worker	Dell Wyse 7040	Intel Core i5-6500TE processor
	Intel® NUC	Intel Core i5-5300U processor with Intel® vPro™ technology
	Lenovo ThinkCentre M900p Tiny	Intel Core i7-6700T processor

Applications and Workloads Tested

The applications and workloads we tested fell into three categories:

- **Virtualized applications**—We tested the latency of accessing commonly used applications (such as Skype® for Business) through Citrix XenApp® (see [Virtualized Application Access](#)).
- **Locally installed applications**—We tested the performance of collaboration applications on devices that can accommodate local installations (see [Locally Installed Application Performance](#)).
- **Specialized resource-intensive applications and multitasking workloads**—We tested the responsiveness of standard office applications and specialized medical applications, particularly with multiple applications running at the same time (see [Resource-Intensive Application Performance](#) and [Multitasking](#), respectively).

Note on our test environment: We tested everything over Ethernet to simulate a real-world clinical setting in which Ethernet has traditionally been preferred to wireless connections.

Virtualized Application Access

Virtually every medical worker in a clinical setting needs access to the EMR application, either exclusively or along with other applications.

In our test scenarios, users logged in to Citrix® StoreFront™ (the Citrix enterprise app store for accessing XenApp® applications), accessed the athenahealth® Epocrates® Online point-of-care application through the Google™ Chrome™ browser in XenApp, and used Skype for Business through XenApp.



More powerful processors are

21–155% faster

for working in XenApp®.

Recommendation: Any of the devices tested work for most users, but higher-end devices are a good choice for knowledge workers, who tend to be power users and multitaskers.

Virtualized-Application Test Highlights

Logging in to Citrix® StoreFront™

- No devices delivered unacceptably slow performance.
- The Dell™ Wyse™ 3030 LT and Lenovo® ThinkCentre® M700 Tiny are the fastest of the tested task-worker devices.
- All knowledge-worker devices performed comparably and, as expected, were faster than the task-worker devices.
 - The slowest knowledge-worker device (the Intel® NUC) is **21% faster** than the fastest task-worker device (the Dell Wyse 3030 LT).

Using Skype® for Business through Citrix XenApp®

- No devices provided unacceptably slow performance.
- The Intel® Compute Stick is the top performer of the task-worker devices, with the Lenovo ThinkCentre M700 Tiny being the slowest.
- All knowledge-worker devices performed comparably to each other and to the task-worker devices.

Accessing athenahealth® Epocrates® Online through Citrix XenApp®

- All devices perform adequately, but the knowledge-worker devices performed best.
- The Dell Wyse 3030 LT and Lenovo ThinkCentre M700 Tiny are the fastest of the task-worker devices and resulted in **50% less waiting** than the Intel Compute Stick.
- All knowledge-worker devices with higher-end processors performed comparably and, as expected, faster than the task-worker devices with less-powerful processors.
 - The fastest knowledge-worker device (the Dell Wyse 7040) is **155% faster** than the slowest task-worker device (the Intel Compute Stick).

For details on the specifics of these tests, see Appendices [B](#), [C](#), [D](#), and [E](#).

Locally Installed Application Performance

Most healthcare workers need to collaborate with colleagues, often remotely. Greater device performance can reduce frustration and save time for everyone in remote meetings—particularly when initiating a video conference or presenting materials through unified communications applications, such as Skype for Business.



More powerful processors are **29% faster** for collaboration in Skype® for Business.

To simulate this situation, we created a test scenario in which a user shares an X-ray image with colleagues by showing his desktop and sending the image as an attachment in Skype for Business during a video conference call. The video conference call is conducted through Skype for Business running locally on the device when possible.

Recommendation: When performance matters, a locally installed application yields significant productivity gains. In addition, devices with more powerful processors allow for faster completion of collaboration tasks.

Locally Installed–Application Test Highlights

Screen sharing through Skype® for Business (locally installed)

- The Dell™ Wyse™ 3030 LT and the Lenovo® ThinkCentre® M700 Tiny do not have enough memory to install apps locally.
- All knowledge-worker devices perform comparably to each other.
- Comparing knowledge-worker and task-worker devices, the Lenovo ThinkCentre M900p Tiny is **29% faster** than the Intel® Compute Stick.

The biggest difference in overall performance came when using Skype for Business running locally on the devices as compared to accessing it through XenApp. An example of this was the performance of the Intel Compute Stick (see Table 2).

Table 2. Time to share a file through Skype® for Business remotely through Citrix XenApp® and with Skype for Business installed locally

Skype® for Business over Citrix XenApp®		Skype for Business installed locally	
Intel® Compute Stick	17.88 seconds	Intel Compute Stick	4.73 seconds

(Smaller numbers are better)

IT'S ALL IN THE PROCESSOR

Healthcare IT teams can expect the same or similar Intel® processors that power the thin clients we tested to deliver comparable performance when powering laptop or 2-in-1 devices.

For details on the specifics of these tests, see Appendices [B](#), [C](#), [D](#), and [E](#).

Resource-Intensive Application Performance

Some medical applications are more resource- or graphics-intensive than others. An example is a PACS, a specialized application to view and annotate medical-image files (such as X-rays or computerized-tomography scans). Dictation software also benefits from more computational horsepower on the client device.

In one of our test scenarios, a radiologist reviews an X-ray image in ObjectiveView™ Digital Pathology Image Viewer, a PACS, and makes annotations to later review with the patient’s physician. In another scenario, a clinician uses Dragon® Medical, installed locally on the device, to quickly transcribe her patient recorded patient notes to text.



The Intel® Core™ i7 processor is **63% faster** for medical transcription than other processors tested.

Recommendation: Computationally demanding applications (such as a PACS) perform faster with more powerful processors. Healthcare IT teams want to consider issuing fully functional thin clients or even laptops or 2-in-1s to knowledge workers who rely on such applications to provide them with both the computational power and mobility they need.

Resource-Intensive Application Test Highlights

Reviewing and annotating an X-ray image with ObjectiveView™ Digital Pathology Image Viewer

- All devices tested performed well for process times—all within 0.3 seconds of each other.
- The Lenovo® ThinkCentre® M900p Tiny was **18% faster** than the Intel® NUC and **6% faster** than the Dell™ Wyse™ 7040.
- This is what we expect due to the faster processor in the Lenovo ThinkCentre M900p Tiny.

Dictating patient-examination notes with Dragon® Medical

- The Lenovo ThinkCentre M900p Tiny outperformed the other devices:
 - **63% faster** than the Intel NUC and **29% faster** than the Dell Wyse 7040 on raw processing time.
 - **30% faster** than the Intel NUC and **6% faster** than the Dell Wyse 7040 for both tests combined.
- The Dell Wyse 7040 is **19% faster** than the Intel NUC.

For physicians and physicians’ assistants who transcribe exam notes, the Lenovo ThinkCentre M900p Tiny is the optimal device from those tested for transcription due to its faster processor.

For details on the specifics of these tests, see Appendices [B](#), [C](#), [D](#), and [E](#).

Multitasking

Task workers, such as nurses, nurse assistants, and front-office staff, typically perform only one or two tasks simultaneously on a device. But knowledge workers, such as doctors, technicians, administrators, and IT staff, are often power users who have multiple applications open and running simultaneously. For any of these workers, background processes, such as antivirus scans, might also be running.



Multitasking is **62% faster** with more powerful processors compared to less powerful processors.

To examine a multitasking workload on our test devices, we ran two scenarios: one with a smaller workload for applications that might be run in a virtualized environment and one with a heavier workload that included specialized applications and Microsoft® Office 365®.

Recommendation: The systems we tested all work well for knowledge and task workers who need to multitask on a few applications and maximize productivity. For knowledge workers who perform intensive multitasking, the Lenovo® ThinkCentre® M900p Tiny, with its Intel® Core™ i7-6700T processor, is the most efficient device and can shave minutes off a busy knowledge worker's day.

Multitasking Test Highlights

Running a virtualized-application, multitasking workload (Skype® for Business and athenahealth® Epocrates® Online) over Citrix XenApp® with antivirus software running locally in the background

All devices handle this load comparably well.

Running a virtualized-application workload (athenahealth® Epocrates® Online) over Citrix XenApp® with Google™ Chrome™, Microsoft® PowerPoint®, ObjectiveView™ Digital Pathology Image Viewer, Dragon® Medical, and Skype® for Business running locally, in addition to antivirus running locally in the background

The Lenovo® ThinkCentre® M900p Tiny outperforms the other knowledge-worker devices at **62% faster** than the Intel® NUC and **26% faster** than the Dell™ Wyse™ 7040 for raw processing times (to be expected given the faster processor in the Lenovo ThinkCentre M900p Tiny).

For details on the specifics of these tests, see Appendices [B](#), [C](#), [D](#), and [E](#).

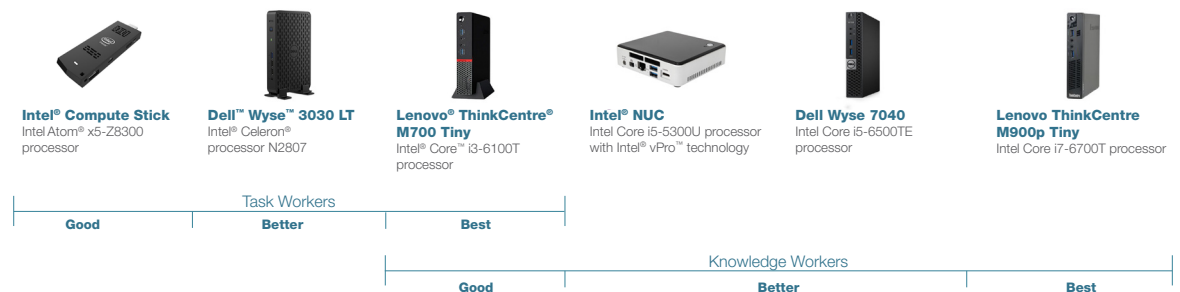
Conclusion: Match the Client to the User

Adopting thin clients for certain users can be a logical decision for healthcare organizations that utilize application or desktop virtualization, a common method for delivering EMR access. To ensure that the performance of devices meets the demands of various application workloads, IT is best served when it documents user requirements as part of the process of selecting the right devices for users. In addition to users' existing needs, we recommend considering emerging user needs, such as collaboration tools, which are becoming increasingly popular with organizations looking to improve the coordination of care.

Fortunately for healthcare IT, thin clients come equipped with a variety of performance levels and in a variety of form factors. Most popular vendor platforms also come with a variety of management solutions for deploying and managing a thin-client fleet. Our testing underscores a number of points about the necessity of appropriately matching performance to users' roles. Keep in mind that although testing was performed on small-form factor and desktop devices, the resulting performance differences also apply to mobile devices, such as laptops or 2-in-1s, powered by the same or comparable processors.

Figure 1 aligns worker roles to the devices for which they are best suited based on our testing. (Note: Our testing indicates that the Lenovo ThinkCentre M700 Tiny could serve both task workers and knowledge workers equally well.)

Figure 1. Recommended devices by worker role



Regardless of the form factors you choose, help provide top performance and reliability for the users who depend on you and your team by deploying devices powered by Intel processors. When you pick a device powered by the right processor for your users' needs, you can keep those users productive and focused on providing exceptional patient care.

Appendix A: Hardware and Test Environment

Hardware Devices						
	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny	Dell Wyse 7040	Intel® NUC	Lenovo ThinkCentre M900p Tiny
Processor	Intel Atom® x5-Z8300 processor	Intel® Celeron® processor N2807	Intel® Core™ i3-6100T processor	Intel Core i5-6500TE processor	Intel Core i5-5300U processor	Intel Core i7-6700T processor
Model	STCK1A32WFC	N06D	10JQ-CT01WW	D10U	NUC5i5MYHE	10FM-CT01WW
Processor Speed (GHz)	1.33 GHz	2.10 GHz	3.20 GHz	2.50 GHz	2.30 GHz	2.80 GHz
Storage (GB)	28.2 GB	3 GB	8 GB	106 GB	167 GB	237 GB
Memory (GB)	2 GB	1.5 GB	14.9 GB	8 GB	16 GB	8 GB
Graphics	Intel® HD Graphics	Integrated graphics	Integrated graphics	Integrated graphics	Intel HD Graphics 5500	Integrated graphics
Ports	1 x USB 2.0 Bluetooth® 4.0 microSD® card slot	1 x USB 3.0 3 x USB 2.0	6 x USB 3.0	6 x USB 3.0	2 x USB 2.0 2 x USB 3.0	2 x USB 3.0 Up to 4 x USB 3.0
Audio	Intel® High Definition Audio via HDMI	Internal speakers	Intel High Definition Audio	Not Applicable (NA)	Intel High Definition Audio	NA
Networking	802.11bgn wireless	10/100/1000 Base-T gigabit Ethernet	802.11 a/c WLAN	Intel® Dual Band Wireless 8260 (802.11ac) + Bluetooth	Intel Gigabit LAN NIC	802.11a/b/g/n/ac
System Weight (lbs)	0.12 lbs	5.20 lbs	1.30 lbs	3.12 lbs	2.40 lbs	1.30 lbs
Additional Hardware						
External 1,920 x 1,200 monitor set to 1,440 x 900 resolution						

Software						
	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny	Dell Wyse 7040	Intel® NUC	Lenovo ThinkCentre M900p Tiny
Operating System	Windows® 10 Home	Wyse OS	Windows Embedded Standard	Windows 10 Pro	Windows 10 Pro	Windows 10 Enterprise
Microsoft® PowerPoint® (Microsoft® Office 365® Pro Plus)	NA	NA	NA	16.0.6965.2115	16.0.6965.2105	16.0.6965.2105
Skype® for Business 2016	15.0.4885.1000	NA	NA	16.0.6925.1048	16.0.6925.1044	16.0.6925.1044
Dragon® Medical Practice Edition	NA	NA	NA	2	2	2
McAfee® LiveSafe™	NA	NA	NA	14	14	15.1
ObjectiveView™ Digital Pathology Image Viewer	NA	NA	NA	1.46	1.46	1.46
Google™ Chrome™	55.0.2883.87	NA	NA	55.0.2883.87	55.0.2883.87	55.0.2883.87
Microsoft Edge™	38.14393.0.0	NA	NA	20.10240.17146.0	38.14393.0.0	38.14393.0.0
Internet Explorer®	NA	NA	8.0.7601.17514	NA	NA	NA

File Sizes Used in Testing Use Cases	
X-ray image (.jpg)	524 KB
Microsoft® PowerPoint® file (.ppt)	55.5 MB
Audio recording (.mp3)	6.0 MB
Microsoft® Word® file (.docx)	12.3 KB

For this report, Prowess Consulting tested the performance differences between devices in two different functional tests. We recorded both the raw processing times for completing each task (covered in Appendices B and C) and the times that the tester spent completing tasks while interacting with the devices and applications—the human element (covered in Appendices D and E).

Appendix B: Processor-Only Functional-Test Steps

Virtualized-Application Tests Steps

Log In to Citrix® StoreFront™

1. Start the timer.
2. Type **password**, press **Enter**, wait for the application to fully load.
3. Stop the timer.

Access athenahealth® Epocrates® Online Through Citrix XenApp®

Start Google™ Chrome™

1. Start the timer.
2. From the taskbar, click the **Chrome** icon, and wait for the browser to load.
3. Stop the timer.

Load a Website

1. Start the timer.
2. Click **Epocrates** bookmark, and wait for the website to load.
3. Stop the timer.

Select a Medication

1. Start the timer.
2. Click **oxycodone/ibuprofen**, and wait while the information loads.
3. Stop the timer.

Use Skype® for Business Through XenApp®

Open XenApp Desktop

1. Start the timer.
2. Click **Everyone**, and wait for the desktop to load.
3. Stop the timer.

Present Desktop

1. Start the timer.
2. Click **OK**, and wait for desktop to be presented.
3. Stop the timer.

Share a File

1. Start the timer.
2. Click **Open**, and wait for file to be transferred.
3. Stop the timer.

Locally Installed–Application Tests Steps

Use Skype for Business (Locally Installed)

Present Desktop

1. Start the timer.
2. Click **OK**, and wait for desktop to be presented.
3. Stop the timer.

Share a File

1. Start the timer.
2. Click **Open**, and wait for file to be transferred.
3. Stop the timer.

Resource-Intensive Application Tests Steps (Locally Installed)

Review and Annotate an X-ray Image in ObjectiveView™ Digital Pathology Viewer

Open ObjectiveView

1. Start the timer.
2. Double-click **ObjectiView**, and wait for the application to load.
3. Stop the timer.

Open X-Ray File

1. Start the timer.
2. Open **CSpine4of4.jpg**.
3. Stop the timer.

Dictate Patient-Examination Notes in Dragon® Medical—Transcribe from a Recording

Open Dragon Medical

1. Start the timer.
2. Double-click **Dragon Medical**, and wait until the application fully opens.
3. Stop the timer.

Transcribe from a Recorded File

1. Start the timer.
2. Click **Transcribe**, and wait for transcription to finish.
3. Stop the timer.

Save Transcribed File

1. Start the timer.
2. Click **Save**, and wait for file to finish saving.
3. Stop the timer.

Dictate Patient-Examination Notes in Dragon® Medical—Transcribe from Spoken Word

Open Dragon Medical

1. Start the timer.
2. Double-click **Dragon Medical**, and wait until the application fully opens.
3. Stop the timer.

Save Transcribed File

1. Start the timer.
2. Click **Save**, and wait for file to finish saving.
3. Stop the timer.

Multitask Tests Steps

Run a Virtualized-Application, Multitasking Workload (Skype for Business and Epocrates Online) over XenApp with Antivirus Software Running Locally in the Background

Log In to XenApp

1. Start the timer.
2. Type **password**, press **Enter**, and wait for the application to fully load.
3. Stop the timer.

Present Desktop

1. Start the timer.
2. Click **OK**, and wait for desktop to be presented.
3. Stop the timer.

Share a File

1. Start the timer.
2. Click **Open**, and wait for file to be transferred.
3. Stop the timer.

Load Website

1. Start the timer.
2. Click **Epocrates** bookmark, and wait for the website to load.
3. Stop the timer.

Select a Medication

1. Start the timer.
2. Click **oxycodone/ibuprofen**, and wait while the information loads.
3. Stop the timer

Run a Virtualized-Application Workload (Epocrates Online) over XenApp with Google™ Chrome™, Microsoft® PowerPoint®, ObjectiveView, Dragon Medical, and Skype for Business Running Locally and Antivirus Software Running Locally in the Background

Start Chrome

1. Start the timer.
2. From the taskbar, click **Chrome**, and wait for the browser to load.
3. Stop the timer.

Log In to XenApp

1. Start the timer.
2. Type **password**, press **Enter**, and wait for the application to fully load.
3. Stop the timer.

Open Microsoft® PowerPoint®

1. Start the timer.
2. From the taskbar, click the **PowerPoint** icon, and wait for PowerPoint to open fully.
3. Stop the timer.

Save a PowerPoint presentation

1. Start the timer.
2. Click **Save**, and wait for the file to fully save.
3. Stop the timer.

Present Desktop

1. Start the timer.
2. Click **OK**, and wait for desktop to be presented.
3. Stop the timer.

Share a File

1. Start the timer.
2. Click **Open**, and wait for file to be transferred.
3. Stop the timer.

Load a Website

1. Start the timer.
2. Click **Epocrates** bookmark, and wait for the website to load.
3. Stop the timer.

Select a Medication

1. Start the timer.
2. Click **oxycodone/ibuprofen**, and wait while information loads.
3. Stop the timer.

Open ObjectiveView

1. Start the timer.
2. Double-click **ObjectiView**, and wait for the application to load.
3. Stop the timer.

Open X-Ray File

1. Start the timer.
2. Open **CSpine4of4.jpg**.
3. Stop the timer.

Transcribe in Dragon Medical

1. Start the timer.
2. Click **Transcribe**, and wait for the file to transcribe.
3. Stop the timer.

Additional Tests Steps

Boot the Device

Boot the Device

1. Start the timer.
2. Press the power button, and wait for the login screen.
3. Stop the timer.

Log In to the Device

1. Start the timer.
2. Enter the **password** in the corresponding field, press **Enter**, and wait for the desktop to fully load.
3. Stop the timer.

Wake the Device

Wake the Device

1. Start the timer.
2. Press **Enter**, and wait for the login screen.
3. Stop the timer.

Log In to the Device

1. Start the timer.
2. Enter the **password** in the corresponding field, press **Enter**, and wait for the desktop to fully load.
3. Stop the timer.

Access Epocrates Online from a Locally Installed Browser (Chrome) to Check for Drug Interactions

Start Chrome

1. Start the timer.
2. From the taskbar, click the **Chrome** icon, and wait for the browser to load.
3. Stop the timer.

Load a Website

1. Start the timer.
2. Click the **Epocrates** bookmark, and wait for the website to load.
3. Stop the timer.

Select a Medication

1. Start the timer.
2. Click **oxycodone/ibuprofen**, and wait while the information loads.
3. Stop the timer.

Add an Image to a Presentation in PowerPoint 2016

Open PowerPoint

1. Start the timer.
2. From the taskbar, click the **PowerPoint** icon, and wait for PowerPoint to open fully.
3. Stop the timer.

Save a PowerPoint presentation

1. Start the timer.
2. Click **Save**, and wait for file to fully save.
3. Stop the timer.

Appendix C: Details of Processor-Only Functional-Test Results

Virtualized-Application Test Results

Log In to Citrix StoreFront

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Log in to Citrix® StoreFront™	1.31 seconds	0.91 seconds	0.97 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Log in to Citrix® StoreFront™	0.74 seconds	0.75 seconds	0.74 seconds

All times in seconds (smaller is better)

Access athenahealth Epocrates Online Through XenApp

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Access athenahealth® Epocrates® Online and look up medications through Citrix XenApp®	6.23 seconds	3.08 seconds	3.17 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Access athenahealth® Epocrates® Online and look up medications through Citrix XenApp®	2.83 seconds	3.16 seconds	2.86 seconds

All times in seconds (smaller is better)

Use Skype for Business Through XenApp

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Use Skype® for Business through Citrix XenApp®	17.88 seconds	9.73 seconds	14.35 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Use Skype® for Business through Citrix XenApp®	12.56 seconds	12.32 seconds	12.16 seconds

All times in seconds (smaller is better)

Locally Installed–Application Test Results

Video Conference Through Locally Installed Skype for Business

Note: The Wyse 3030 LT and ThinkCentre M700 Tiny lack sufficient memory to install Skype for Business locally.

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Use locally installed Skype® for Business	4.73 seconds	NA	NA

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Use locally installed Skype® for Business	4.61 seconds	5.04 seconds	4.96 seconds

All times in seconds (smaller is better)

Resource-Intensive-Application Test Results

Review and Annotate an X-ray Image in ObjectiveView Digital Pathology Viewer—Knowledge-Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Open locally installed ObjectiveView™ and annotate an image	6.78 seconds	6.98 seconds	6.75 seconds

All times in seconds (smaller is better)

Dictate Patient-Examination Notes in Locally Installed Dragon® Medical—Knowledge Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Transcribe recording	169.49 seconds	213.29 seconds	130.93 seconds
Transcribe from spoken word	17.49 seconds	17.59 seconds	13.77 seconds

All times in seconds (smaller is better)

Multitask Test Results

Run a Virtualized-Application, Multitasking Workload (Skype for Business and Epocrates Online) over XenApp with Antivirus Software Running Locally in the Background —Knowledge-Worker Devices Only

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Multitask on locally installed apps and apps through Citrix XenApp®	8.08 seconds	7.48 seconds	7.56 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Multitask on locally installed apps and apps through Citrix XenApp®	60.84 seconds	86.62 seconds	57.36 seconds

All times in seconds (smaller is better)

Run a Virtualized-Application Workload (Epocrates Online) over XenApp with Chrome, PowerPoint, ObjectiveView, Dragon Medical, and Skype for Business Running Locally and Antivirus Software Running Locally in the Background

Knowledge-Worker Device	Dell™ Wyse™ 7040	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Multitask on locally installed apps and apps through Citrix XenApp®	172.63 seconds	233.59 seconds	143.96 seconds

All times in seconds (smaller is better)

Additional Test Results

Boot the Device

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Boot the device	35.41 seconds	63.74 seconds	22.99 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Boot the device	20.06 seconds	21.95 seconds	19.13 seconds

All times in seconds (smaller is better)

Wake the Device

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Wake the device	0.39 seconds	0.48 seconds	0.50 seconds

All times in seconds (smaller is better)

Access Epocrates Online from a Locally Installed Browser (Chrome) to Check for Drug Interactions—Knowledge-Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Access athenahealth® Epocrates® Online and look up medications	2.63 seconds	3.57 seconds	2.83 seconds

All times in seconds (smaller is better)

Add an Image to a Presentation in PowerPoint 2016—Knowledge-Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Multitask using a locally saved Microsoft® PowerPoint® file	3.00 seconds	4.03 seconds	2.92 seconds

All times in seconds (smaller is better)

Times shown are the median of three test runs. Margins of error run from +/-0.1 percent to +/-10.0 percent. Tests were run using an Ethernet network connection.

Appendix D: Human-Element Functional-Test Steps

For this report, Prowess Consulting tested the performance differences between devices in two different functional tests. We recorded both the raw processing times for completing each task and the times that the tester spent completing tasks while interacting with the devices and applications—the human element. Human-element results were used for the performance metrics in this report and are included here.

Virtualized-Application Tests Steps

Log In to Citrix StoreFront

1. Start the timer.
2. From the taskbar, click the **Microsoft Edge** icon.
3. Click the **XenApp** bookmark. (Note you will need to have created this bookmark before testing.)
4. Enter **username** and **password** in the corresponding fields, press **Enter**, and wait for the application to fully load.
5. Stop the timer.

Access athenahealth Epocrates Online Through XenApp

1. Start the timer.
2. From the desktop, double-click the **Google Chrome** icon on your desktop.
3. Click the **Athenahealth Epocrates Online** bookmark. (Note you will need to have created this bookmark before testing.)
4. From the top menu, select **Interaction Check**.
5. Click **Sign in**.
6. Enter **email address** and **password** in the corresponding fields.
7. Click **Login**.
8. In the **Add a Drug** box, type **Naproxen**, and press **Enter**.
9. In the **Add a Drug** box, type **Oxycodone**, and press **Enter**.
10. Stop the timer.

Use Skype for Business Through XenApp

1. Start the timer.
2. Double-click a contact's name in Skype for Business.
3. Click the **video** icon.
4. Click **Start My Video**.
5. Click the **Present** icon.
6. Select **Present Desktop**.
7. Click **OK** on the warning message.
8. Click **Stop Presenting**.
9. Click the **paper clip** icon.
10. Select **Documents**.
11. Select **CSpine4of4.jpg**.
12. Click **Open**, and wait for the image to share to the recipient device.
13. Stop the timer.

Locally Installed–Application Tests Steps

Use Skype for Business (Locally Installed)

1. Start the timer.
2. Double-click a contact's name in Skype for Business.
3. Click the **video** icon.
4. Click **Start My Video**.
5. Click the **Present** icon.
6. Select **Present Desktop**.
7. Click **OK** on the warning message.
8. Click **Stop Presenting**.
9. Click the **paper clip** icon.
10. Select **Documents**.
11. Select **CSpine4of4.jpg**.
12. Click **Open**, and wait for the image to share to the recipient device.
13. Stop the timer.

Resource-Intensive-Application Tests Steps (Locally Installed)

Review and Annotate an X-ray Image in ObjectiveView Digital Pathology Viewer

Open ObjectiveView

1. Start the timer.
2. From the desktop, double-click the **ObjectiveView** icon.
3. Click **File**.
4. Click **Open File**.
5. Click **Documents**.
6. Double-click **CSpine4of4.jpg**, and wait for it to open.
7. Stop the timer.

Annotate an Image

1. Start the timer.
2. Click **Annotation Tool**.
3. Click the **ruler** icon.
4. Click and drag from the base of the skull in the image to the top of the fifth vertebra to draw a line.
5. In the text box, type **DB: What are your thoughts on this?**
6. Click **Annotation Tool** again.
7. Click the **pointer** icon.
8. Click and drag from the top of the seventh vertebra to the left to make a pointer.
9. In the text box, type **DB: Does this look okay to you?**
10. From the top-right corner of the application, click the **X** symbol to close the application.
11. When prompted, click **Yes**.
12. Stop the timer.

Dictate Patient-Examination Notes in Dragon Medical

Transcribe from a Recording

1. Start the timer.
2. From the desktop, double-click the **Dragon Medical** icon.
3. Click **Tools**.
4. Click **Transcribe Recording**.
5. Click **Next**.
6. Click **Browse** to locate your recorded audio file.
7. Click **Documents**.
8. Double-click your recorded audio file.
9. Click **Transcribe**.
10. Once finished, click the **X** in the top right corner of the application to close it.
11. When prompted, click **Yes**.
12. Select **Documents**.
13. Type a filename.
14. Click **Save**.
15. Stop the timer.

Transcribe from Spoken Word

1. Start the timer.
2. From the desktop, double-click the **Dragon Medical** icon.
3. Click the red box at the top left of the window to turn on the microphone on your device.
4. Read your examination notes.
5. Click the red box at the top left of the window to turn off the microphone.
6. Click **Save**.
7. Select **Documents**.
8. Type a filename.
9. Click **Save**.
10. Stop the timer.

Multitask Tests Steps

Run a Virtualized-Application, Multitasking Workload (Skype for Business and Epocrates Online) over XenApp with Antivirus Software Running Locally in the Background

Log In to XenApp

1. Start the timer.
2. Type **password** in the corresponding field, press **Enter**, and wait for the application to fully load.
3. Stop the timer.

Conduct a Skype for Business Video Conference

1. Start the timer.
2. From the desktop, double-click the **Skype for Business** icon.
3. Double-click a contact's name in Skype for Business.
4. Click the **video** icon.
5. Click **Start My Video**.
6. Click the **Present** icon.
7. Select **Present Desktop**.
8. Click **OK** on the warning dialog.
9. Click **Stop Presenting**.
10. Click the **paper clip** icon.
11. Select **Documents**.
12. Select **CSpine4of4.jpg**.
13. Click **Open**, and wait for the file to open on the recipient device.
14. Stop the timer.

Check a Drug Interaction

1. Start the timer.
2. From the desktop, double-click the **Chrome** icon.
3. Click the **Epocrates Online** bookmark. (Note you will need to have created this bookmark before testing.)
4. From the top menu, select **Interaction Check**.
5. Click **Sign in**.
6. Enter your **email address** and **password** in the corresponding fields.
7. Click **Login**.
8. In the **Add a Drug** box, type **Naproxen**, and press **Enter**.
9. In the **Add a Drug** box, type **Oxycodone**, and press **Enter**.
10. Stop the timer.

Run a Virtualized-Application Workload (Epocrates Online) over XenApp with Chrome, PowerPoint, ObjectiveView, Dragon Medical, and Skype for Business Running Locally and Antivirus Software Running Locally in the Background

Log In to XenApp

1. Start the timer.
2. From the taskbar, click the **Edge** icon.
3. Click the **XenApp** bookmark. (Note you will need to have created this bookmark before testing.)
4. Type **username** and **password** in the corresponding fields, press Enter, and wait for the applications to fully load.
5. Stop the timer.

Insert an image in PowerPoint

1. Start the timer.
2. From the taskbar, click the **PowerPoint** icon.
3. Click **Open Other Presentations > Browse > Documents**.
4. Double-click the presentation to open.
5. In the left-hand pane, click the number of the slide to which you will add the image.
6. Click **Insert**.
7. Click **Picture**.
8. Double-click the image to add.
9. Click **File > Save As > Documents**, type a file name, and press **Enter**.
10. Stop the timer.

Open ObjectiveView

1. Start the timer.
2. From the desktop, double-click the **ObjectiveView** icon.
3. Click **File**.
4. Click **Open File**.
5. Click **Documents**.
6. Double-click **CSpine4of4.jpg**.
7. Stop the timer.

Annotate an Image

1. Start the timer.
2. Click **Annotation Tool**.
3. Click the **ruler** icon.
4. Click and drag from the base of skull to the top of the fifth vertebra to draw a line.
5. In the text box, type **DB: What are your thoughts on this?**
6. Click **Annotation Tool** again.
7. Click the **pointer** icon.
8. Click and drag from the top of the seventh vertebra to the left to make a pointer.
9. In the text box, type **DB: Does this look okay to you?**
10. Stop the timer.

Check Drug Interaction

1. Start the timer.
2. Open a new tab in **Chrome**.
3. Click the **Epocrates Online** bookmark. (Note you will need to have created this bookmark before testing.)
4. From the top menu, select **Interaction Check**.
5. Click **Sign in**.
6. Enter your **email address** and **password** in the corresponding fields.
7. Click **Login**.
8. In the **Add a Drug** box, type **Naproxen**, and press **Enter**.
9. In the **Add a Drug** box, type **Oxycodone**, and press **Enter**.
10. Stop the timer.

Transcribe a Note

1. Start the timer.
2. From the desktop, double-click the **Dragon Medical** icon.
3. Click **Tools**.
4. Click **Transcribe Recording**.
5. Click **Next**.
6. Click **Browse** to locate the audio file.
7. Click **Documents**.
8. Double-click **Janet_Jones_Medical.mp3**.
9. Click **Open**.
10. Click **Transcribe**.
11. Stop the timer.

Conduct a Skype for Business Video Conference

1. Start the timer.
2. Open **Skype for Business**.
3. Double-click a contact's name in **Skype for Business**.
4. Click the **video** icon.
5. Click **Start My Video**.
6. Click the **Present** icon.
7. Select **Present Desktop**.
8. Click **OK** on the warning dialog.
9. Click **Stop Presenting**.
10. Click the **paper clip** icon.
11. Select **Documents**.
12. Select **CSpine4of4.jpg**.
13. Click **Open**.
14. Stop the timer.

Additional Tests Steps

Boot the Device

Boot the Device

1. Start the timer.
2. Press the **power button**, and wait for the login screen.
3. Stop the timer.

Log In to the Device

1. Start the timer.
2. Enter the **password** in the corresponding field, press **Enter**, and wait for the desktop to fully load.
3. Stop the timer.

Wake the Device

Wake the Device

1. Start the timer.
2. Press **Enter**, and wait for the login screen.
3. Stop the timer.

Log In to the Device

1. Start the timer.
2. Enter the **password** in the corresponding field, press **Enter**, and wait for the desktop to fully load.
3. Stop the timer.

Access Epocrates Online from a Locally Installed Browser (Chrome) to Check for Drug Interactions

1. Start the timer.
2. From the taskbar, click the **Chrome** icon.
3. Click the **Epocrates Online** bookmark. (Note you will need to have created this bookmark before testing.)
4. From the top menu, select **Interaction Check**.
5. Click **Sign in**.
6. Enter your **email address** and **password** in the corresponding fields.
7. Click **Login**.
8. In the **Add a Drug** box, type **Naproxen**, and press **Enter**.
9. In the **Add a Drug** box, type **Oxycodone**, and press **Enter**.
10. Stop the timer.

Add an Image to a Presentation in PowerPoint 2016

1. Start the timer.
2. From the taskbar, click the **PowerPoint** icon.
3. Click Open Other **Presentations > Browse > Documents**.
4. Double-click **PH_QuarterlyEmployeeMeeting.ppt** to open.
5. In the left-hand pane, click slide **18**.
6. Click **Insert**.
7. Click **Picture**.
8. Double-click **CSpine4of4.jpg**.
9. Click **File > Save As > Documents**, type **Employee_Presentation**, and press **Enter**.
10. Stop the timer.

Appendix E: Details of Human-Element Functional-Test Results

Virtualized-Application Test Results

Log In to Citrix StoreFront

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Log in to Citrix® StoreFront™	7.57 seconds	6.87 seconds	7.69 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Log in to Citrix® StoreFront™	10.72 seconds	15.39 seconds	12.34 seconds

All times in seconds (smaller is better)

Access athenahealth Epocrates Online Through XenApp

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Access athenahealth® Epocrates® Online and look up medications through Citrix XenApp®	29.56 seconds	33.83 seconds	27.29 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Access athenahealth® Epocrates® Online and look up medications through Citrix XenApp®	26.68 seconds	31.03 seconds	27.88 seconds

All times in seconds (smaller is better)

Use Skype for Business Through XenApp

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Use Skype® for Business through Citrix XenApp®	30.16 seconds	33.68 seconds	32.81 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Use Skype® for Business through Citrix XenApp®	27.58 seconds	32.26 seconds	31.98 seconds

All times in seconds (smaller is better)

Locally Installed–Application Test Results

Video Conference Through Locally Installed Skype for Business

Note: The Wyse 3030 LT and ThinkCentre M700 Tiny lack sufficient memory to install Skype for Business locally.

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Use locally installed Skype® for Business	31.58 seconds	NA	NA

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Use locally installed Skype® for Business	25.69 seconds	29.94 seconds	24.55 seconds

All times in seconds (smaller is better)

Resource-Intensive Application Test Results

Review and Annotate an X-ray Image in ObjectiveView™ Digital Pathology Viewer—Knowledge Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Open locally installed ObjectiveView™ and annotate an image	29.24 seconds	32.56 seconds	27.49 seconds

All times in seconds (smaller is better)

Dictate Patient-Examination Notes in Locally Installed Dragon® Medical—Knowledge Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Transcribe recording	193.59 seconds	254.57 seconds	158.62 seconds
Transcribe from spoken word	138.32 seconds	153.25 seconds	155.62 seconds

All times in seconds (smaller is better)

Multitask Test Results

Run a Virtualized-Application, Multitasking Workload (Skype for Business and Epocrates Online) over XenApp with Antivirus Software Running Locally in the Background

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Multitask on locally installed apps and apps through Citrix XenApp®	67.52 seconds	70.45 seconds	59.72 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Multitask on locally installed apps and apps through Citrix XenApp®	60.75 seconds	80.23 seconds	77.97 seconds

All times in seconds (smaller is better)

Run a Virtualized-Application Workload (Epocrates Online) over XenApp with Chrome, PowerPoint, ObjectiveView, Dragon Medical, and Skype for Business Running Locally and Antivirus Software Running Locally in the Background—Knowledge-Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Multitask on locally installed apps and apps through Citrix XenApp®	172.63 seconds	233.59 seconds	143.96 seconds

All times in seconds (smaller is better)

Additional Test Results

Boot the Device

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Boot the device	39.12 seconds	69.81 seconds	27.72 seconds

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Boot the device	24.50 seconds	24.61 seconds	23.20 seconds

All times in seconds (smaller is better)

Wake the Device

Assumption: A password is needed every time the computer wakes.

Task-Worker Device	Intel® Compute Stick	Dell™ Wyse™ 3030 LT	Lenovo® ThinkCentre® M700 Tiny
Wake the device	2.45 seconds	NA	NA

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Wake computer	9.04 seconds	8.82 seconds	12.28 seconds

All times in seconds (smaller is better)

Access Epocrates Online from a Locally Installed Browser (Chrome) to Check for Drug Interactions—Knowledge Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Access athenahealth® Epocrates® Online and look up medications	24.49 seconds	35.43 seconds	26.85 seconds

All times in seconds (smaller is better)

Add an Image to a Presentation in Microsoft PowerPoint 2016—Knowledge Worker Devices Only

Knowledge-Worker Device	Dell™ Wyse™ 7040	Intel® NUC	Lenovo® ThinkCentre® M900p
Multitask using a locally saved Microsoft® PowerPoint® file	26.28 seconds	37.76 seconds	28.89 seconds

All times in seconds (smaller is better)

Times shown are the median of three test runs. Margins of error run from +/-0.1 percent to +/-10.0 percent. Tests were run using an Ethernet network connection.



The analysis in this document was done by Prowess Consulting and commissioned by Intel.

Results have been simulated and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance.

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