



Digital Workspace Myths Debunked

The Science of Remote Windows Desktop Performance

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DISCLAIMER

This presentation is based on scientific principles and reproducible experimental setups – which is kind of weird in the IT industry!

For some of you, the content may be deeply disturbing. The presenter assumes no responsibility for possible school physics flashbacks with associated physical and mental reactions among participants.

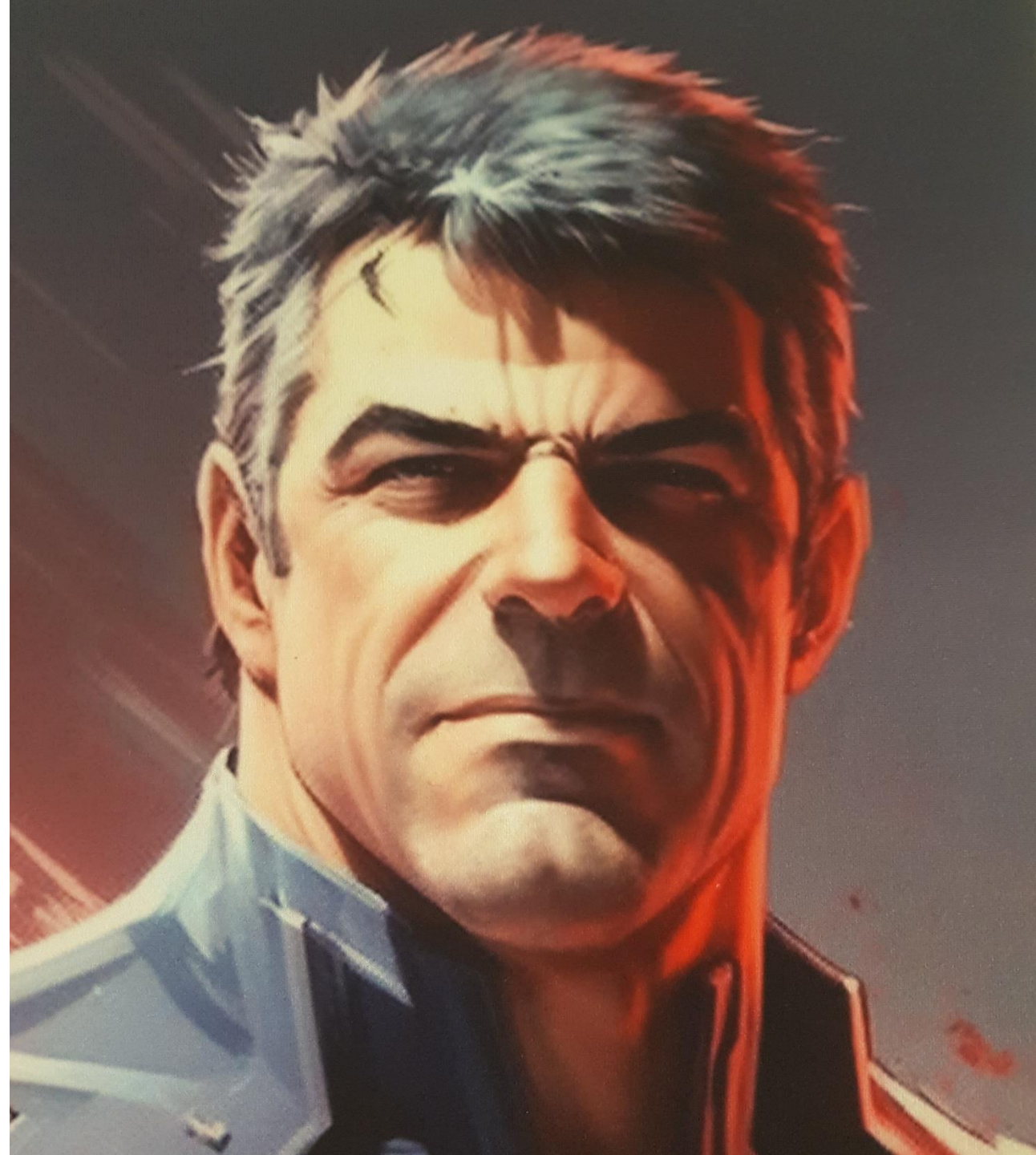


Performance Data Scientist
EUC Documentary Cameraman
MVP | CTP | EUC Expert | NGCA

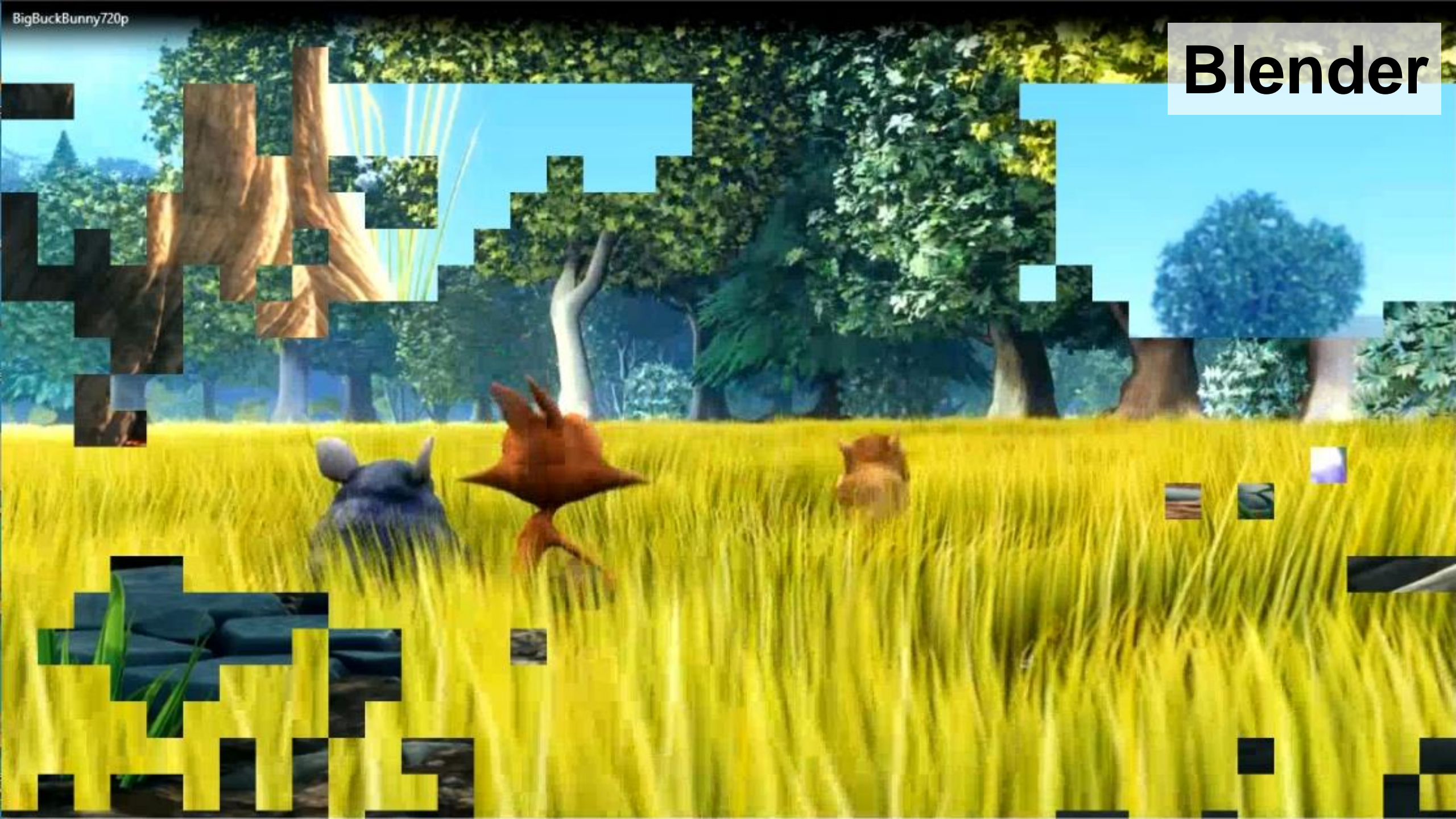


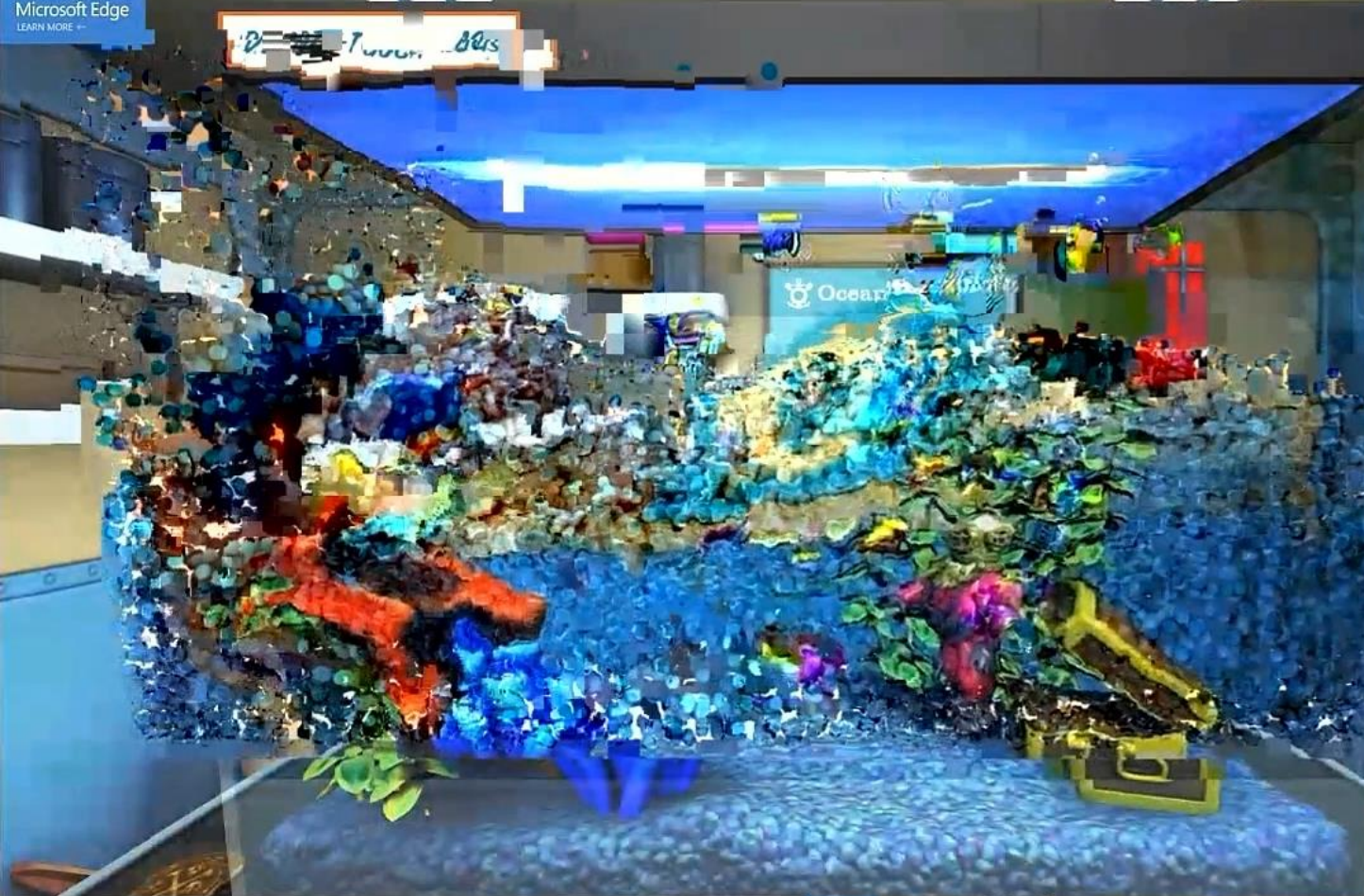
info@drtritsch.com
@drtritsch

“Back off man, I’m a scientist!”
Bill Murray, Ghostbusters, 1984

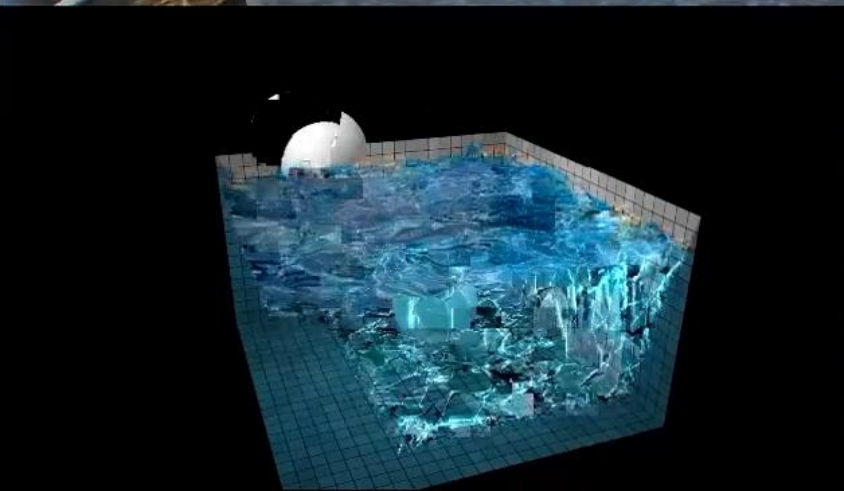


Blender





Videos / Web Apps





Humus/DirectX

EUC Score for AWS



CPU
7% 2.11 GHz

Memory
3.8/15.9 GB (24%)

Disk 0 (C:)
SSD
0%

Ethernet
Ethernet 2
S: 0.1 R: 6.5 Mbps

GPU 0
Intel(R) HD Graphi...
0%

GPU 1
Radeon RX Vega ...
1% (47 °C)



10 Fish

Fish

10 ▾

Layers

- ✓ Water
- ✓ Frame
- ✓ Mask
- ✓ Back
- ✓ Fish
- ✓ Front
- ✓ Shine
- ✓ Shadow
- ✓ Audio
- ✓ Logo
- ✓ FPS
- ✓ Needle



Remoting Protocol Features

Remoting protocols run on top of the Internet Protocol (IP), using Transmission Control Protocol (TCP), User Datagram Protocol (UDP) or a combination a TCP and UDP for different aspects of remoting. While older remoting protocols only used TCP, the modern ones use UDP for the graphics remoting aspect.

TCP is a connection-oriented protocol providing high reliability through error checking, congestion control and a built-in mechanism that rearranges data packets in the order specified. It also guarantees that all data remains intact in the packets transferred. But all this makes TCP relatively heavy-weight, significantly reducing graphics remoting performance on low bandwidth and high latency/packet loss networks.

UDP is a connectionless protocol that provides a simpler, more efficient means of communication. It does not guarantee that data packets will arrive in the order specified or that they will arrive at all. However, its lack of overhead makes it a better choice for graphics remoting, where the loss of a few packets is often preferable to the delay and overhead of TCP's error checking and congestion control.

But there is more to a remoting protocol, in particular when it comes to extensibility. The concept of virtual channels provides a way to establish separate streams of data communication while taking advantage of the remote session communication already established. Many remoting protocols use virtual channels to add functions that allow a strict separation from the core features or are not yet specified in the protocol. They represent a platform that future developments can be based on without having to modify the communication methods between host and clients. Examples for virtual channel use cases are joint client and server clipboards or redirecting print jobs to local client printers.

Other notable remoting protocol features include bi-directional audio transmission, client side command execution, and the ability to redirect local client resources such as printers and drives to the remote host. These features provide a more complete and flexible remoting experience, allowing users to interact with remote systems as if they were local.

Client Side Rendering versus Host Side Rendering

In a graphics remoting environment, the Windows desktop, including its applications is rendered in a

Unigine

Unigine fatal error



HeapPool::init(): can't allocate 33554448 bytes

OK

Glossary – Screen Artifacts / Anomalies

- Block boundary – mosaicking, pixelating, quilting, checkerboarding
- Tiling, striping – rendering each section of an image grid, a tile, or a stripe separately
- Smear artifact – grime, smudge, airbrush effect
- Blurriness – out of focus, fuzziness, unsharpness
- Color artifacts – false colors, color bleeding, color lookup table errors
- Mosquito noise – edge busyness
- Ringing – echoing, ghosting
- Choppy – laggy, jumpy, jerky
- Floating – illusory motion in certain regions while the surrounding areas remain static
- Jitter – loss of transmitted data between network devices
- Flickering – fine-grain flickering and coarse-grain flickering, irregular or unsteady moves
- Slow motion – action appears to be slowed down
- Video stuttering (“micro stutters”) – irregular delays between frames
- Freeze frames – a single frame in a video sequence forming a motionless image

Digital Employee Experience (DEX) can be measured by collecting performance counters on the host side only

The client specs have no impact on remote desktop performance

Remoting protocol A is better than remoting protocol B across all graphics formats

Newer CPUs = better performance

Only network bandwidth matters

Some applications run slower in GPU-enabled virtual desktops

90 frames per second are the minimum requirement for great user experience



Digital Workspace Myths



CMS Experiment at the LHC, CERN

Data recorded: 2009-Dec-16 03:05:08.131031 GMT
Run: 124275
Event: 774693
Lumi section: 3
Orbit: 2735736
Crossing: 51

Tech Triggers:

- 8
- 9
- 10
- 32
- 33
- 34
- 40
- 41
- 42
- 43

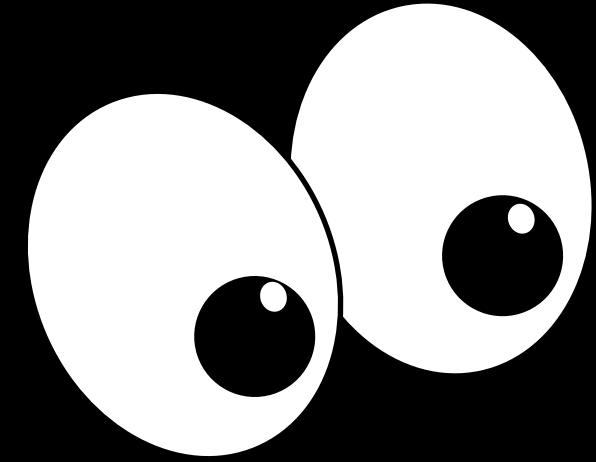
L1 Triggers:

- L1_EG10_Jet15
- L1_EG5_TripleJet15
- L1_MinBias_HTT10
- L1_ZeroBias

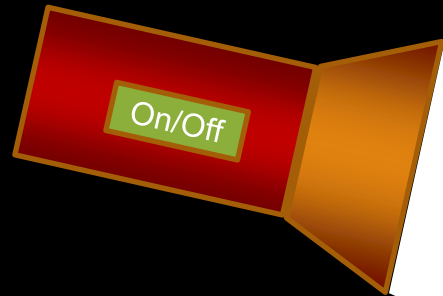
DEX4DaaS

You can only score
and optimize what
you can measure!











That's Why We Need Science

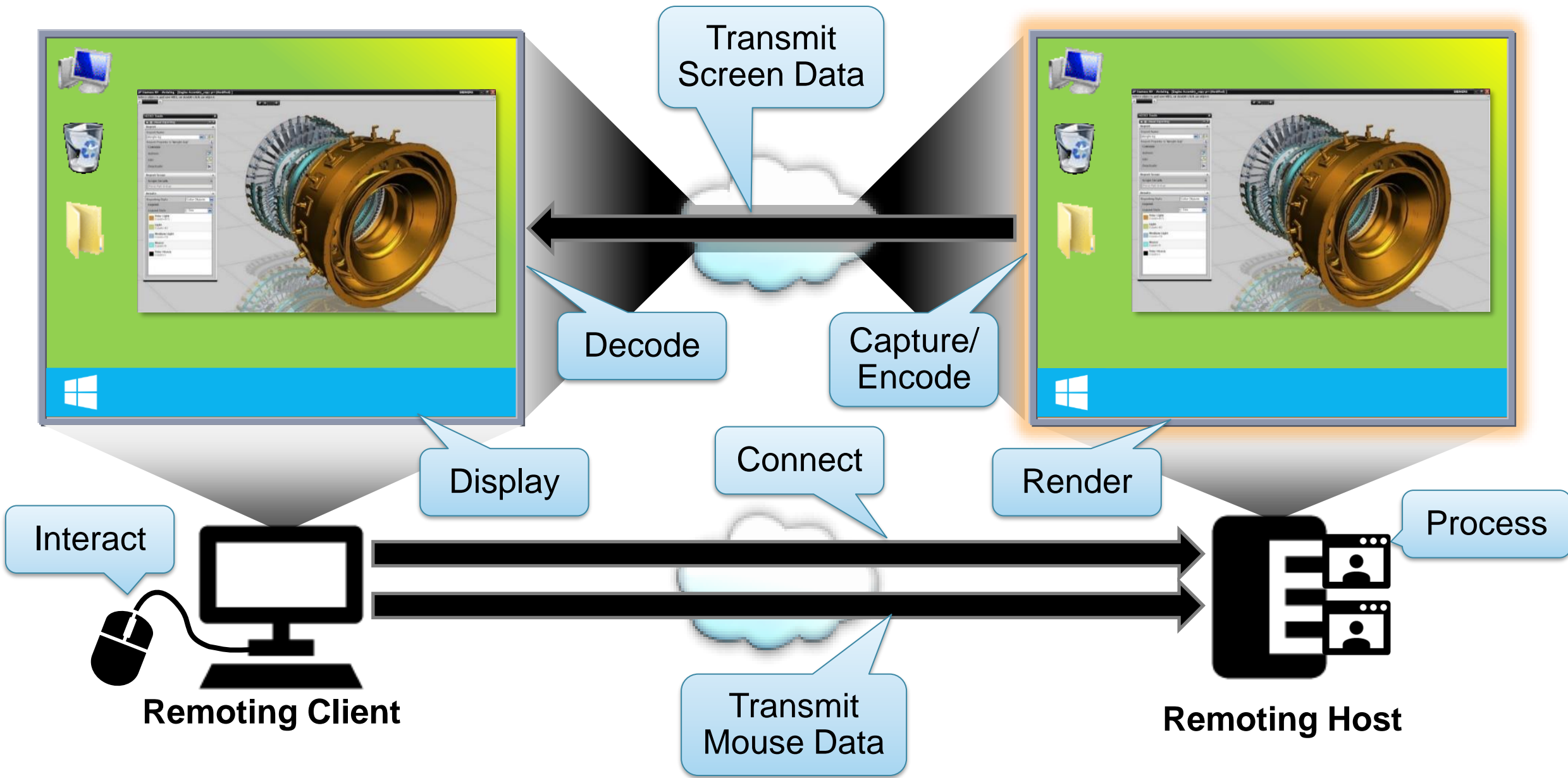


Look before you leap!



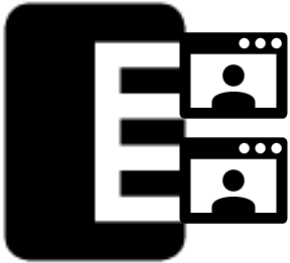
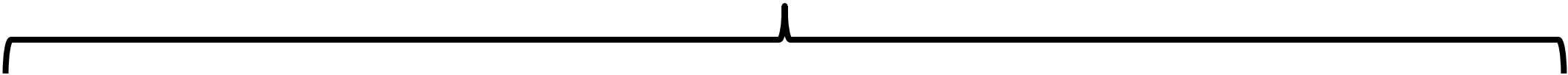
Science of EUC – UX Quality Criteria

	Boot and logon duration	Measure boot time + logon time + user session load time until it is ready for user interaction
	Application and content load time	Measure time from user starting an application until the content appears and the application is ready for user input
	User input delay (“Lag”)	Measures responsiveness of graphical elements after user-initiated triggers = “time from mouse click to screen update” (lag, latency, system response time)
	Graphics APIs supported	Detect incompatibilities when running graphics applications using the DirectX, OpenGL, Vulkan and WebGL APIs
	Media formats supported	Detect incompatibilities when opening media files, such as MP4, MPEG, MOV, WMV or AVI
	Distortion of media	Detect image, animation, and audio/video compression and decompression artifacts and anomalies
	Screen refresh rate	Measure the number of times per second that the desktop or application can draw consecutive images on the screen (frames per second = fps)
	Screen resolution and display size	Determine the number of pixels and density as well as the screen's visual dimensions – frame buffer requirements grow with resolution and screen number
	Application stability	Detect application hangs, freezes, crashes or unhandled exceptions
	Session availability and resilience	Detect user session hangs, disconnects and reconnects



Science of EUC: Performance Influencers

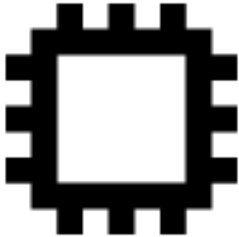
“Remoting Protocol Stack”



Host System
“VM Type”



Client Device
“Endpoint”



GPUs



Network

Science of EUC: Network Factors

The richer the graphics, the more bandwidth it will take



Bandwidth

Data transfer rate of a network connection



Latency

Delay; amount of time to traverse a system



Packet Loss

Discarding of data packets (in percent)

Latency: It's Einstein's Fault...

40,000km \approx 25,000mi



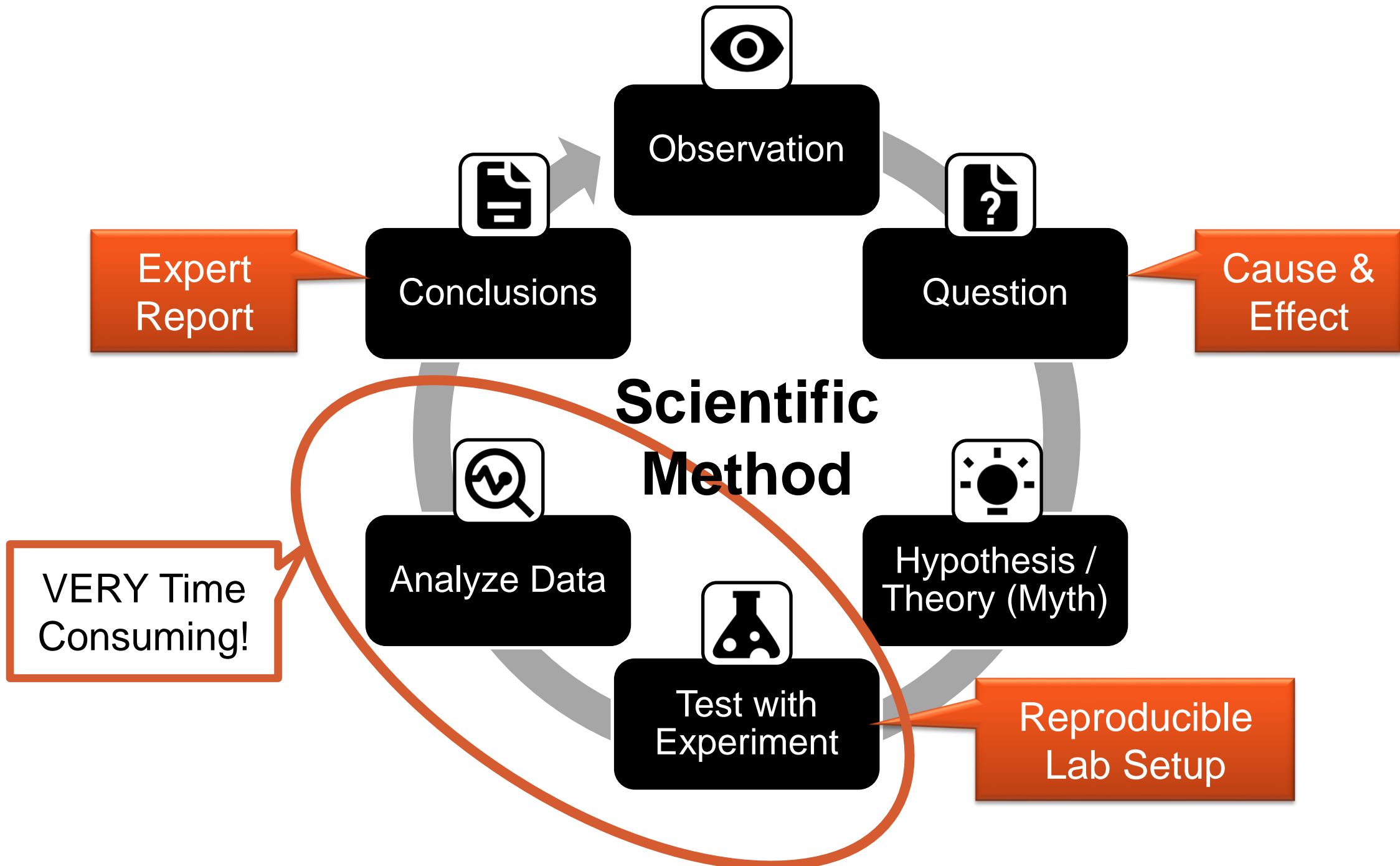
Speed
of light

$c \approx 300,000\text{km/sec}$

186,000mi/sec

VF%	Cable
74–79	Cat-7 twisted pair
77	RG-8/U
67	optical fiber
65	RG-58A/U
65	Cat-6A twisted pair
64	Cat-5e twisted pair
58.5	Cat-3 twisted pair

Minimum velocity factors
for network cables



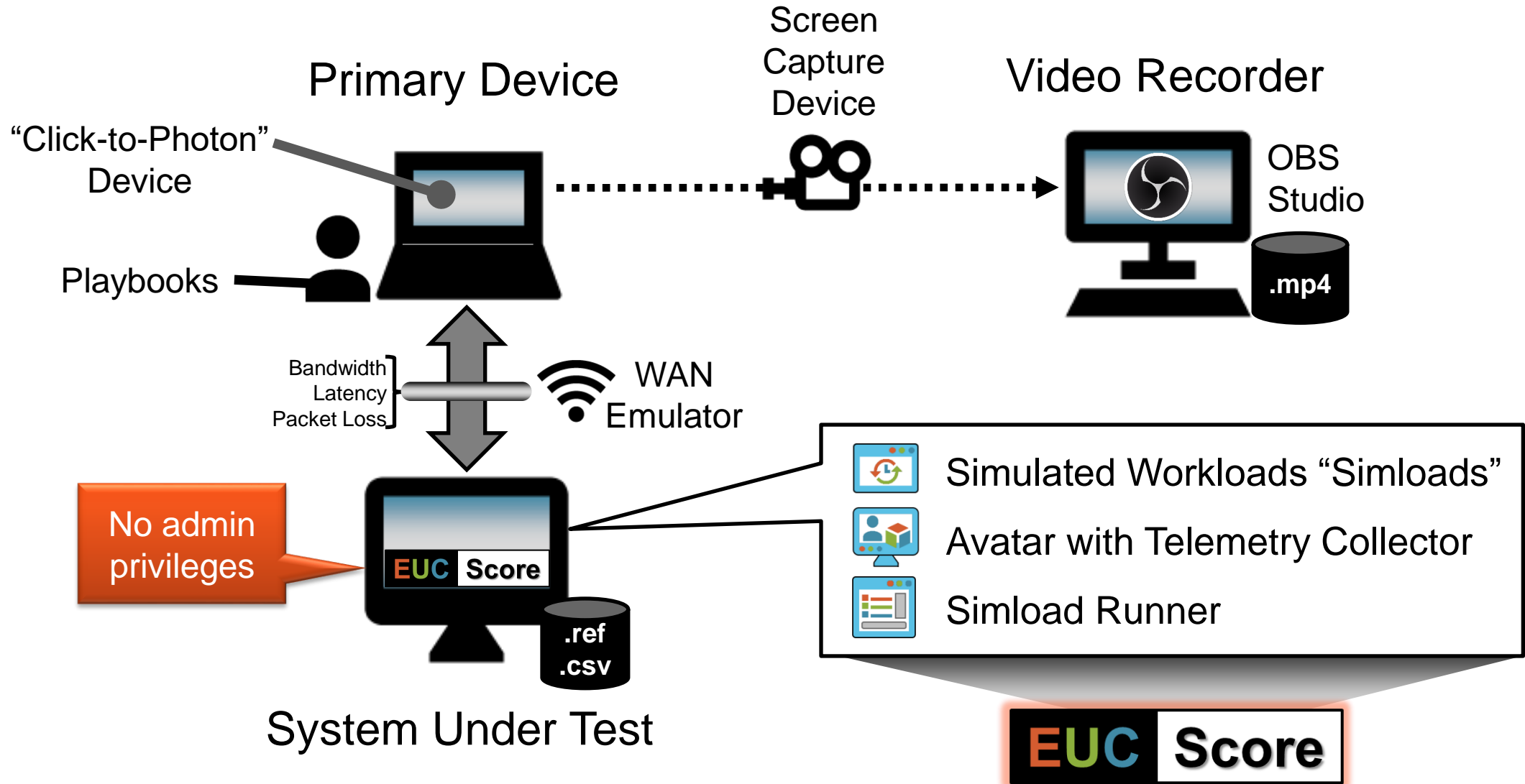
Required Test Lab Components

Digital Employee Experience benchmarking and rating

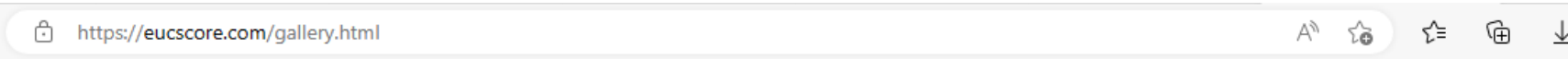
- Simulated Workloads = “Simloads”
- Telemetry Collector (Perf Counters)
- Test Launcher + PowerShell Integration
- [Frame Grabber](#) + Screen Video Recorder
- Sync Player (HTML5) + Build Scripts
- SDK for Custom Simloads
- [WAN Emulators](#)
- “Click-to-Photon” Devices (NVIDIA LDAT)
- Reference Client + Host Machine (Lancelot)

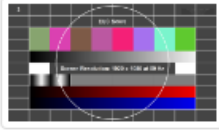



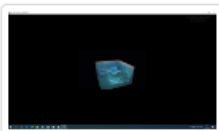
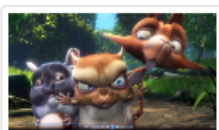



Build a Single-User Test Lab



EUC Score Simload Gallery: <https://eucscore.com/gallery.html>



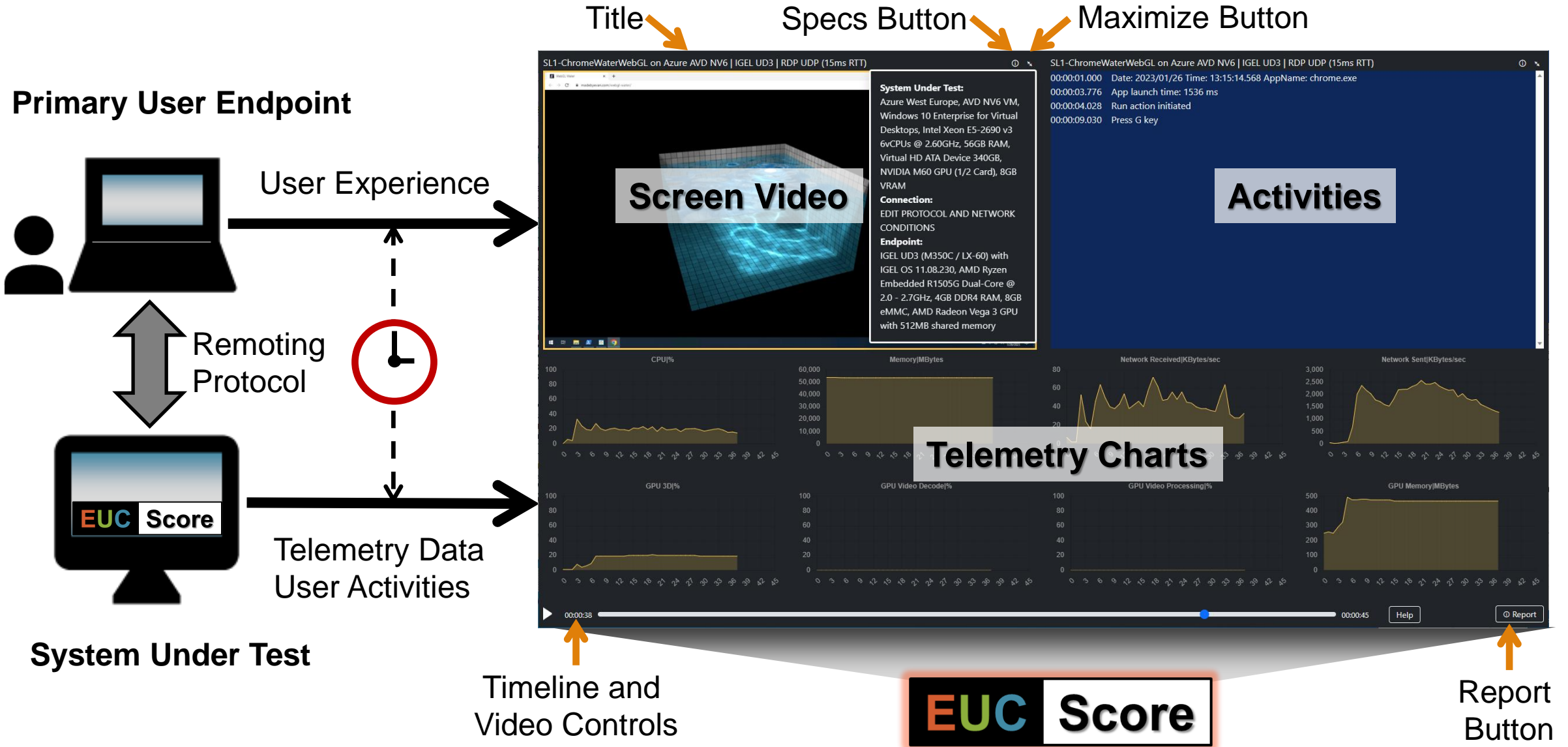
Thumbnail	Simload Type	Description
	System	SL0-TestScreen Open a test pattern screen and save system information.
	Primary Base	SL1-NotepadEdit Open Microsoft Notepad and start writing a novel with random type speed.
	Primary Base	SL1-WordpadScroll Open local DOCX file with PNG images in Wordpad and randomly move pages up and down every second.
	Primary JPEGView	SL1-JPEGViewStatic Open JPEG image in JPEG View. NOTE: This is the most basic Simload as it includes neither animations nor user interactions.
	Primary JPEGView	SL1-JPEGViewAnim Open animated GIF image in JPEG View.
	Primary WMPlayer	SL1-WMPlayer480pWMV Open local 480p WMV video in Windows Media Player, switch from windowed to fullscreen mode.
	Persona Base	SL2-Base Foreground: SL3-AppDialog Background: SL1-JPEGViewAnim

**+ custom
or manual
Simloads
with real user
playbooks**

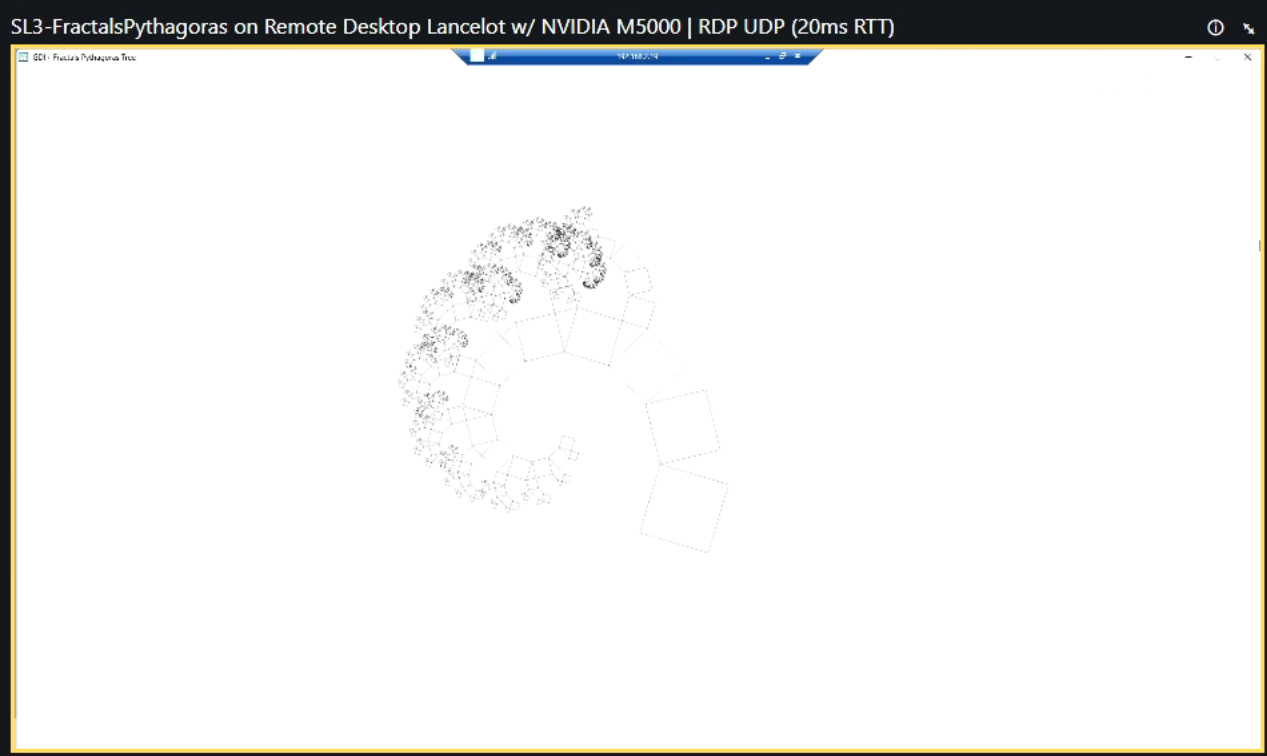


Show Time

Visual Data Analytics – Sync Player







Science of EUC: Human Timings

Nervous System

- Speed of nerve impulse is 120 meters per second
- Human response time is 150-300ms (varies with age)
- Equals to 15,000 – 30,000 km of fiber cables

Visual System

- 24 to 30 frames per second are required for video or motion
- Most desktop monitors' refresh rate is 60 Hz (=16ms)
- The brain can process visual data from a single image in 13ms
- Flicker up to 500 Hz

Auditory System

- Range of human hearing is 20 to 20,000 Hz
- Decibel (dB) measures the force of the sound wave (0-120dB, log.)
- Minimal time interval between two sounds is 3-30ms
- Interaural: 10-20 μ s



The Horse in Motion by Eadweard Muybridge
"Sallie Gardner" running at a 1:40 gait over the Palo Alto track, on 19th June 1878

Measure Response Times

0.1 second

- System is reacting instantaneously
- No special feedback is necessary except to display the result
- Limit for users feeling that they are directly manipulating objects in the UI

1.0 second

- User's flow of thought stays uninterrupted, even though the user will notice the delay
- Normally, no special UI feedback is necessary
- Limit for users feeling that they are freely navigating the command space

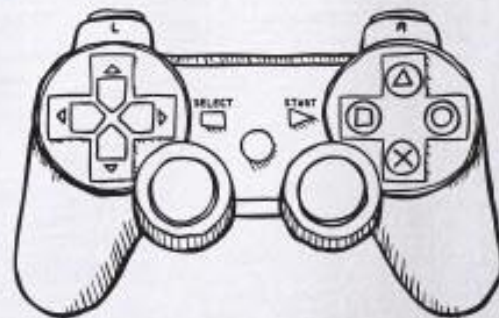
10 seconds

- Limit for users keeping their attention on the task
- User should be given feedback indicating when the computer expects to be done

VIDEO GAMES

DON'T MAKE

US VIOLENT








LAG DOES

DoD: MIL-STD-1472F/G (1999, 2012)

TABLE V. Acceptable system response times.

System Interpretation	Response Time Definition	Time (seconds)
Key response	Key depression until positive response, e.g., “click”	0.1
Key print	Key depression until appearance of character	0.2
Page turn	End of request until first few lines are visible	1.0
Page scan	End of request until text begins to scroll	0.5
XY entry	From selection of field until visual verification	0.2
Pointing	From input of point to display point	0.2
Sketching	From input of point to display of line	0.2
Local update	Change to image using local data base, e.g., new menu list from display buffer	0.5
Host update	Change where data is at host in readily accessible form, e.g., a scale change of existing image	2.0
File update	Image update requires an access to a host file	10
Inquiry (simple)	From command until display of a commonly used message	2.0
Inquiry (complex)	Response message requires seldom used calculations in graphic form	10
Error feedback	From entry of input until error message appears	0.2

Science of EUC: DEX Personas

	Persona Name	Rendering	IT Workforce	Description
	Task Worker	CPU	25-80%	Well-defined, repetitive, and delineated tasks, using a limited number of applications
	Information Worker	CPU or shared GPU	25-80%	Find facts quickly, create documents, edit, write & process information
	Knowledge Worker	High-end CPU or shared GPU	10-50% ~400m	Tasks include accessing the Internet, using email, and creating complex documents, presentations, and spreadsheets
	Power User	Shared GPU or dedicated GPU	5-50% ~200m	People who use multiple compute, network and graphics-intensive applications
	CAD/CAM Professional Designer	Dedicated GPU	5-25% ~25m	People who use graphically-intense applications for computer-aided design (CAD) and computer-aided manufacturing (CAM)



Findings
EUC Market Changes



Cloud workstations for CAD, BIM and visualisation
How the major public cloud providers stack up

In-depth technical report

Using Frame, the Desktop-as-a-Service (DaaS) solution, we test 23 GPU-accelerated 'Instances' from Amazon Web Services (AWS), Google Cloud Platform (GCP), and Microsoft Azure, in terms of raw performance and end user experience.

By Greg Corke

While benchmarking helps to understand the relative performance of different VMs, it doesn't consider what happens between the datacentre and the end user

It's a common belief in public cloud workstations that the performance of the public cloud, and certainly more specifically the major public cloud providers, is the same. However, this is not the case. There are a number of different factors that can affect the performance of a public cloud, and these factors can vary significantly between providers. This is why it's important to benchmark the performance of different public cloud providers, and to understand what happens between the datacentre and the end user.

While benchmarking helps to understand the relative performance of different VMs, it doesn't consider what happens between the datacentre and the end user. This is why it's important to benchmark the performance of different public cloud providers, and to understand what happens between the datacentre and the end user.

Author: Greg Corke, DEVELOP3D's Managing Editor and resident workstation specialist

- <https://ux.fra.me/>
- <https://aecmag.com/workstations/cloud-workstations-for-cad-bim-and-visualisation/>
- <https://develop3d.com/workstations/summer-2023-workstation-special-report/>



Findings
VM Types and
Remoting Protocols

Instance	CPUZ - ST	CPUZ - MT	CBR23 - MC	CBR23 - SC	EUX 2023	EUC Score App Dialog	EUC Score App Start	EUC Score GDI+ Fractals Dragon	EUC Score GDI+ Fractals Pythagoras	EUC Score GDI+ Rectangles	EUC Score IOPS	Price	EUC Score GDI+ /Price	EUX Score /Price
	better▶	better▶	better▶	better▶	better▶	◀better	◀better	◀better	◀better	◀better	◀better			
Microsoft Azure														
Azure NV6	256	1789	3843	671	7.37	0.28	0.62	8.71	15.31	1.55	5.57	1.33	6.41	5.54
Azure NV4as_v4	348	997	2304	893	7.95	0.29	0.68	106.89	194.31	1.3	14.08	0.47	214.54	16.91
Azure NV8as_v4	375	2107	4673	937	8.25	0.29	0.65	26.52	49.36	1.05	6.34	0.94	27.29	8.78
Azure NV16as_v4	395.7	4246	9445	945	8.03	0.29	0.66	10.36	20.83	1.3	3.98	1.88	5.76	4.27
Azure NV32as_v4	395.4	8414	17896	959	8.37	0.29	0.65	4.3	8.96	1.18	2.88	3.76	1.28	2.23
Azure NC4asT4_v3	365.8	1490	2988	909	8.22	0.28	0.61	4.21	8.58	1.08	11.3	0.81	5.68	10.11
Azure NC8asT4_v3	376.7	3059	7029	942	8.3	0.28	0.61	4.14	8.21	1.12	3.92	1.24	3.62	6.69
Azure NC16asT4_v3	395.9	6020	13959	956	8.28	0.28	0.61	4.52	8.87	1.16	3.67	2.14	2.27	3.87
Azure NV6adsA10_v5	494.4	2105.2	4895	1273	8.41	0.28	0.57	36.32	78.85	0.73	5.26	0.82	47.29	10.29
Azure NV12adsA10_v5	511.7	4016	9818	1309	8.36	0.28	0.57	19.12	36.42	0.82	2.68	1.63	11.50	5.12
Azure NV36adsA10_v5	548.8	12821	26897	1310	8.4	0.28	0.56	3.8	7.91	0.82	1.9	5.47	0.76	1.54

Price in US\$/hour (global average)

Quantitative results, no exact science

A man in a dark suit and glasses is sitting at a desk in an office, looking at a computer monitor. He is using a mouse with his right hand. The monitor displays a web application with various data fields and buttons. In the background, another person is partially visible, also working at a computer. The office environment includes a desk with papers, a mug, and a window with blinds.

Challenges DEX Quality Criteria

Call to Action

If you want to learn more about the science of EUC Score projects, send an email to

info@eucscore.com



<https://eucscore.com>

<https://eucscore.com/results>

NOTE: The EUC Score toolset is free for community benchmarking tests when the results are made publicly available



EUC Score Links

- Home page: <https://eucscore.com/>
- Test Methodology: <https://eucscore.com/methodology.html>
- Toolset documentation: <https://eucscore.com/docs/index.html>
- Simload Gallery: <https://eucscore.com/gallery.html>
- Test Results (Sync Player): <https://eucscore.com/results>
- Terminology (Glossary): <https://eucscore.com/terminology.html>
- Lab Equipment: <https://eucscore.com/equipment.html>



Thank You

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