Best Practices Guide for Using Adobe Creative Cloud Video Applications in AWS Virtual Machines

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Executive Summary

This document details how Adobe and Amazon recommend running video production workloads on virtual machines on AWS using desktop virtualization. These workloads require more GPU, CPU, Memory, storage space, and storage IO bandwidth than typical virtual environments, and are more complex to deploy at scale. As there are many different configurations that work for the various scenarios, the authors have focused on three primary scenarios with which to provide guidance:

• News & Simple Edits
• Full Creative Workflow
• Promo Graphics

The guidance will detail deployment methodologies, virtual machine sizing, storage, and hardware device compatibility issues and if followed can provide agility and scalability in scenarios supported by Amazon and Adobe.

Remote vs Cloud Production

In the context of this document, 'remote production' will be defined as the process of accessing existing infrastructure, including corporate on-premise storage, networking and workstations, from a remote location. In contrast, ‘cloud production’ will be understood to be the process of accessing and using a public or private datacenter for media production.

This guide only addresses the functional specifications of running Adobe Premiere Pro, Adobe After Effects, and Adobe Media Encoder in Amazon's public cloud environment.
Why is VDI important for the Media and Entertainment industry

When looking at the business case of moving workflows to the cloud it’s important to review not only the cost but the wider efficiencies and productivity that can be realized. Resources in the cloud, including workstations and storage, are billed based on consumption with rates tailored to their technical specifications, therefore in some applications it is more cost-effective to purchase a local workstation rather than a powerful GPU equipped workstation 24/7 in the cloud. To really understand the benefit that VDI can bring to the Media and Entertainment industry we need to look broader, at the less quantifiable metrics:

Flexibility/scalability

For businesses with unpredictable/episodic workloads, or with a predominantly freelance-based workforce, it is not financially viable to invest in hardware that will only really get fully utilized during peaks in the business calendar/production cycle. Working in the cloud offers an attractive alternative, as it requires minimal upfront investment yet still gives the business a framework to dynamically scale to meet the need for additional high-powered workstations, network and storage, as and when required.

Fostering better cross-team collaboration

By moving media workflows to the cloud, businesses get the opportunity to securely store and create media without needing to care any longer about its physical location. When media is stored centrally, it can easily and quickly be distributed to datacenters close to the talent—enabling Advertising Agencies to use the best/most cost-effective local freelance talent, Publishing and News organizations to implement truly round-the-clock ‘follow the sun editing’ and Broadcasters to more efficiently work with third parties on a global basis.

Improved, not diminished, security

A common (and now outdated) misconception around cloud is that it is somehow less secure than on-premise. However, this prejudice no longer holds water, with cloud now trusted for everything from securing government assets to delivering copyright-protected Hollywood blockbusters, cloud workflows pass even the most stringent security tests set by regulators.

In daily practice, that means the cloud allows businesses to know where their media is at all times with actually greater visibility of who has accessed what and when, than traditional storage and access methods. Coupling cloud-based production with Multi-Factor Authentication (MFA) and integration into active directory also creates an environment where all data is maintained within corporate-controlled security boundaries, with IT able to control access to sensitive data in a strict permissions and policy-based regime.

Insights into actual data usage

Another benefit of migrating production to the cloud that might not be immediately apparent; access to usage data that can be extracted from virtual machines and other parts of the cloud infrastructure. Monitoring what your team is doing at a granular level can then be integrated into every level of a cloud stack, allowing operations to collate data, segment and attribute it to users, projects or departments, producing useful insight into working patterns and producing properly data-driven management reporting.
Reduction of your carbon footprint

It is no longer acceptable to send an army of creatives to cover international events—not only due to the cost, but also for the environmental impact of burning so much jet fuel when the cloud offers such a compelling location-agnostic alternative. Protocols such as NDI and SRT now also enable production teams to deploy everything from vision mixers, commlinks and graphic overlays in the cloud to editors situated in a central location. Coupling this with VDI and cloud editing, and you can cover events with essentially skeleton-level crew deployment.

Guaranteed Business Uptime

Traditional Disaster Recovery strategies center around moving whole departments or businesses to new locations in the event of a disaster, something particularly true for media departments that relied on specialist technology to do their job. However, advances in Virtual Desktop Infrastructure (VDI) technology now mean that full video workflows can be located in the cloud.

Add in the fact that many businesses are already utilizing low cost cloud storage for on-premise Work In Progress (WIP) storage back-up means cloud-delivered VDI becomes the obvious choice when considering Disaster Recovery options that negate the need to build or rent expensive physical off-site Business Continuity facilities.

Now we have reviewed the primary business drivers for cloud-based production, let’s drill down a little further into making this a practical step for your team via the Adobe tool-set.

When should VDI be considered?

VDI is actually very well suited to many common media workflows. The business case for moving applications such as animation, motion graphics and VFX to cloud is solid, as all require access to high-performance workstations, and often benefit from the scalable render farms that are readily available in the cloud.

Additionally, VDI can work extremely well to support many typical editing scenarios. In this document we have define the three main candidates for VDI as the following user personas: News/Sports, Creative, and Promo. For each, we have assembled representative programs and tested them in the VDI configurations detailed below so as to verify feature compatibility and acceptable performance.

To see if this solution works in your context, we recommend that you find the workflow instantiated in our four models that aligns closest to your own, then start with the tested configuration. Be aware that it is easy to change the RAM, CPU, and GPU configurations we have employed to suit your specific requirements—but don’t forget that since cloud resources are billed by the hour, short-term experiments can potentially end up as quite inexpensive. The good news here is that the proxy workflows in Premiere can allow big savings on storage, network bandwidth, as well as RAM/CPU/GPU requirements.

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1 See [this page](#) for more information on using proxies in Premiere Pro.
When should it not?

However, there are workflows where VDI performance is limited, and until certain limitations are removed in the technology these should still be prioritized for now as best conducted with on-premise solutions.

Grading /Finishing

Any workflows that require complete frame accuracy, flawless color fidelity and bespoke hardware are always going to be difficult to run in the cloud if they are expected to deliver the quality colorists and specialists demand.

Audio workflow

At present, it is only possible for the PCoIP protocol to transmit a stereo signal to an endpoint. Therefore, any work that requires the listening and mixing of more than two audio streams is not currently possible using VDI. Additionally, recording voice overs directly to VDI in the cloud is currently not deliverable.

Review and approve

At present all VDI protocols support two screens. Therefore, most review and approval workflows, where a third screen is required for the client to view, is difficult to accomplish ‘out of the box’ with VDI solutions. There are workarounds using NDI or third-party managed service providers but be clear that this often necessitates some configuration.

Enabling Technology

Teradici Cloud Access Software

For high-end video editing in the cloud, the solution of choice is Teradici Cloud Access Software which uses the PC-over-IP (PCoIP) protocol. PCoIP technology uses advanced display compression to deliver a secure, high-definition and highly responsive virtualized computing alternative to a local computer. This architecture reaps the benefits of centralized storage and data collaboration while each virtual workstation compresses, encrypts and transmits only display pixels ensuring a highly secure enterprise environment. PCoIP is renowned for delivering a color-accurate video editing experience to a broad range of software clients, mobile clients, thin clients and stateless PCoIP Zero Clients. In addition to default performance settings, a set of protocol enhancements known as ‘PCoIP Ultra offer expanded choice of the most efficient hardware or software codecs according to efficiency objectives. For example, users working at high-resolution monitors (e.g. 4K/UHD) can select PCoIP Ultra CPU enhancements to ensure a highly interactive and high frame rate experience while maintaining color accuracy. Users can also gain CPU relief by offloading encoding functions to the GPU or those operating over highly constrained networks can select the bandwidth efficient chroma sub-sampling mode offered by PCoIP Ultra GPU enhancements.

All testing for this guide was performed using Teradici PCoIP under default configuration settings.

Zero client vs Software Client

There are three options for establishing a PCoIP session with remote Windows or Linux desktops locally; Software, Zero and Thin Client. Each option is suited to different VDI scenarios:
**Software Client**
A software client is an application that acts as a PCoIP end point. Once installed, it allows laptops and workstations to create a secure connection to a Virtual Machine. A software client is perfect for users who would like to access a Virtual Machine on their existing hardware.

**Zero Client**
A zero client is a small form factor machine with minimal processing powers and no storage. Typically, it only has enough ports to connect a keyboard, mouse, monitor and an ethernet cable. Essentially it acts as a gateway to processing power and services available in the cloud. These machines tend to cost around $300 and may be of high interest for organizations who are invested in VDI as a desktop replacement to traditional workstations. If there is no existing infrastructure that can be used to host a software client and the creative users only need base functionality (1080p, 30FPS single monitor), then a Zero Client approach can pay real dividends.

**Thin Client**
To help users in the media and entertainment industry run 4K, 60FPS workflows, Teradici offers PCoIP Ultra, a new protocol that dynamically adapts, encodes and delivers accurate and distortion-free representation regardless of network conditions. However, to run PCoIP Ultra it requires additional processing at the PCoIP endpoint to decode the stream. That means that users who require a 4K, 60FPS local output will need either a thin client or a software client running on a workstation to do the job.

**Connection Broker**
A Connection Broker is a management layer that negotiates the relationship between the cloud provider and the user. In the context of VDI a Connection Broker’s job is to manage the allocation and distribution of Virtual Machines, System Images, protocols and settings across an enterprise environment, whilst ensuring that the cloud environment is securely integrated into the corporate Active Directory for security and compliance. When managing at a handful of instances, it may not necessary to use a Connection Broker, however, when managing multiple users over a number of geographies a Connection Broker is vital for create a secure and cost-effective VDI environment.

When dealing directly with managed service offerings from third parties and cloud providers, the management features of a Connection Broker are included. For enterprise users who want to manage their own environment, the two main options are Teradici Cloud Access Manager and the Leostream Connection Broker.

**Teradici Cloud Access Manager**
Teradici Cloud Access Manager is a cloud service that simplifies and automates deployments of Cloud Access Software, the leading PCoIP® solution for remotely hosted enterprise applications. Cloud Access Manager enables highly scalable and cost-effective Cloud Access Software deployments by managing cloud compute costs and enabling secure user entitlements by brokering PCoIP connections to remote Windows or Linux desktops and workstations, all from a single console. Use of Cloud Access Manager is included with your Teradici PCoIP license.
The architecture above outlines a virtual workstation deployment in the public cloud. Hybrid deployments incorporating the use of on-premises workstations with Cloud Access Manager are also supported. Refer to the Teradici Cloud Access Manager datasheet for further details.

Leostream Connection Broker
Leostream is a remote access and virtual machine management platform for on-premises and cloud hosted desktops. Leostream pools control the capacity and power state of VDI instances hosted in the public cloud, ensuring adequate VDI instances are available based on user demand while minimizing compute costs. Leostream integrates with a variety of multi-factor authentication systems, providing secure access to hosted environments. Leostream is agnostic to the platform, display protocol, and remote and client operating system, allowing organizations to satisfy any user need, managed and access from a single pane of glass.

Amazon WorkSpaces
Amazon WorkSpaces is a managed, secure Desktop-as-a-Service (DaaS) solution. You can use Amazon WorkSpaces to provision either Windows or Linux desktops in just a few minutes and quickly scale to provide thousands of desktops to workers across the globe. You can pay either monthly or hourly, just for the WorkSpaces you launch, which helps you save money when compared to traditional desktops and on-premises VDI solutions. Amazon WorkSpaces helps you eliminate the complexity in managing hardware inventory, OS versions and patches, and Virtual Desktop Infrastructure (VDI), which helps simplify your desktop delivery strategy. With Amazon WorkSpaces, your users get a fast, responsive desktop of their choice that they can access anywhere, anytime, from any supported device.

At the time of this writing, Amazon WorkSpaces supports the NVIDIA Tesla M60-enabled Graphics and GraphicsPro instance types providing a Windows 10 experience powered by Windows Server 2016.
The guidance in this document does not apply to AWS WorkSpaces, since the complexity and performance requirements of video production are better met by the NVIDIA Tesla T4 powered AWS EC2 G4dn instance.

Workflow Considerations

Where is my media?
If your media is already in the cloud, it doesn’t necessarily mean that it is going to be edit-ready. To get the ROI you want from VDI production, make sure it is in the right region, in the right tier of storage, available at the right time, and most importantly visible and accessible to the user. This can be managed either through custom architecture, or by using a number of the third-party cloud storage vendors.

Where is my team?
Just because you want to edit in the cloud doesn’t necessarily mean you can. Users need to be within a certain physical distance from a datacenter to get a minimum viable experience. If you have a team in Europe accessing media that is actually on the West Coast of the US, there is no way that the users will have an enjoyable or productive experience… light travels fast, but it can only travel so fast! In some cases, it might make sense to architect cross-region replication in the cloud or even use a tool to transfer media between the two locations. However, it is worth highlighting that moving media between regions will result in egress costs.

What are my codecs?
Codecs have an important impact not just on the performance but also the financial viability of editing in the cloud. The difference in infrastructure required for editing multiple streams of 4k 60FPS footage is vastly different to that of a proxy edit workflow; you will need higher performance storage, higher performance virtual machines, greater storage capacity and faster network speeds. It is important to consider whether what was done on-premise needs to be replicated in the cloud, therefore, or if a ‘cloud ready’ version of the media would suffice for the workflow.

Note that Premiere Pro’s proxy and reconform workflow is a great option for reducing the costs and improving the user experience. See this document for more information.

What are my collaboration (Project Sharing) needs?
If collaboration is a key part of the edit workflow, then Adobe Team Projects can be utilized to allow multiple users to easily share and collaborate on Premiere Pro and After Effects projects. Couple Team Projects with a proxy workflow, and you have a great set of tools for collaborating across multiple cloud regions or between on premise and the cloud, without incurring expensive egress charges.

What hardware do I need (Wacom, third monitor)?
What on-premise physical appliance do you need in order to edit? Many simple solutions, such as Wacom tablets and second monitors, are configured to use with cloud virtual machines today, but requirements such as a third ‘confidence’ monitor, 5.1 audio and other bespoke USB interfaces are either not possible at present or require bespoke configuration. To create a user experience
comparable to an on-premise workstation it might be necessary to configure the latency of the hardware.

**How many users (growth, temporary, etc.) do I have to worry about?**

Whilst the number of users that can edit in the cloud is theoretically infinite, businesses still need to design their cloud infrastructure with the same consideration that they take when deploying an on-premise edit facility. Central to that thinking is being conscious that it is still vital to ensure your storage is specified to match the workflow requirements - i.e., if there are 20 users, all accessing multiple streams of ProRes HQ, then the cloud storage needs to be architected to ensure guaranteed IOPs.

**Location of Testing**

Planning for PCoIP traffic on a public and private network are critical steps in developing a robust design architecture for a creative desktop deployment. A properly designed environment ensures that the PCoIP protocol can deliver the expected experience to your end users, wherever you are located.

When you are looking at key considerations for the PCoIP protocol there are some factors that need to be taken into consideration, specifically latency, jitter and taking care of the available bandwidth to the PCoIP agent. This means the ability to guarantee network quality, including being able to provide a Quality of Service (QoS), network sizing and minimize packet loss. Each of these factors has an impact on the desktop experience for the user.

To help understand this let's look at each of them and see how these can impact the user:

**Latency and Jitter**

These two issues are really linked together, as when you have high latency on a latency you will see a UDP network protocol (what PCoIP uses to transmit its data over) will drop packets rather than ask for re-sending (which is what a standard TCP protocol will do). What this means is that if you get dropped packets, you will see the desktop not updating or slowing down. The PCoIP protocol can adjust for higher latencies, but if you want to keep that down to 250ms for a round trip time from the agent to the host and back to the agent for a normal desktop—but when you start to look at a creative desktop, you want to keep that below more like 120ms due to the higher demands of a video environment.

Jitter is another factor which needs to be considered; if you see a jitter on the network of more than $\pm 30$ms then you will start to see an inconsistent desktop experience. On a creative desktop you will start to see out-of-sync keyboard input to video display, or out-of-sync audio and video, for example.

**Bandwidth**

Requirements for bandwidth for a creative cloud desktop is another key factor. As a creative desktop has typically more movement then a normal desktop and PCoIP only sends the pixels that are changing on the screen, you need to plan for that. In addition to this, screen resolution, monitor count, video use, and audio in the environment will also impact bandwidth requirements to the PCoIP agent. It’s not just the video requirement but also audio and USB devices that need to be considered, in effect.
To get started in sizing, we typically reserve 10% of total bandwidth off the top for non-view high priority traffic like VOIP if required of the remaining bandwidth, we try to guarantee up to 80% for PCoIP. Here’s an example for calculating bandwidth for PCoIP. Assume 20 concurrent users in the ‘Creative Desktop profile doing 1920 X 1080, 30fps on two monitors. We will need about 10 Mbps per session on average per the table above.

10 Mbps * 20 = 200Mbps
200 Mbps represents 80% of our total available bandwidth after reserving 10% for VOIP, we have to add 20% to 200 Mbps.

200 Mbps + 20% = 240Mbps

If 20% (40Mbps more in this case) is not sufficient for your web and other application traffic, add more.

Finally, add our 10% for VOIP and other high priority traffic.

240 Mbps + 10% = 264Mbps

We need 264 Mbps of bandwidth at a minimum to support these 20 Creative Desktop users.

Now add in audio at the default 500kbps for 20 users for an extra 10 Mbps.

Then, factor in bursting for PCoIP (500kbps or 1 Mbps per session). Let’s assume that not all users will burst at the same time – maybe 20% of our users will concurrently burst by 1 Mbps.

We also need to look at bursting for video as well. For a 30 fps workload this is typically 45 Mbps, so 20% of users will burst which is 9 Mbps

So, Audio 1 Mbps and Video 9 Mbps = 10 Mbps

Thus, the preferred total solution bandwidth looks like this:

264 Mbps PCoIP, Web, VOIP, and general WAN traffic
+ 10 Mbps for PCoIP Audio
+ 10 Mbps for PCoIP burst
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284 Mbps to support 20 Creative Desktop Users

Clearly, a Creative Desktop PCoIP enterprise solution can demand a decent amount of bandwidth for creative users. These requirements must come into play with deciding if users can work from home and planning office networks.

Also, be clear that when you overlay bandwidth requirements and limitations around latency and jitter with the demands of a creative application means that enterprise network planning becomes very important.
With basic connectivity decisions and sizing done, we will now briefly look at other architectural design elements important to Creative Desktop environments in an enterprise environment. Firstly, consider any technologies in the path of PCoIP traffic between View Clients and View Security/Connection servers. That’s because Intrusion Protection Services, WAN Optimization, and VPN devices can all cause packets to be dropped, re-ordered, or delayed. This all translates into PCoIP Packet Loss—a major cause of performance issues, negative user experience/perception and PCoIP disconnects.

To avoid this negative user experience, look at your route-switch environment so as to ensure the correct MTU sizes end-to-end, sufficient buffers, QoS, and WRED configuration to help with congestion on routers. There are a significant number of considerations in these areas. Support Partners recommends reviewing the PCoIP Protocol Virtual Desktop Network Design Checklist from Teradici for specific requirements and PCoIP best practices for network design and configuration.

The good news is that with sufficient analysis and planning, there is no reason why you should not have a great cloud based creative desktop experience.

Firewall
When deploying Teradici PCoIP it is worth highlighting that certain ports need to be whitelisted in order for it to work in a corporate environment. These firewalls are highlighted here.

Wacom
When using a Wacom tablet peripheral device in conjunction with a cloud-based virtual workstation, the PCoIP client should be configured to locally terminate the Wacom tablet as outlined in Cloud Access Software Administrator Guides. This ensures that a highly interactive user experience is maintained, despite the latency introduced by the network connection.

Cloud Infrastructure Considerations

Storage
A vital consideration when working in the cloud is the storage. Deciding what type of storage is needed for your workflow is dependent on a number of factors including, number of users, bit rate of the codecs and the budget. Below is a definition of each type of storage, and the ideal use case. Whilst each has benefits, a combined approach will be required to recreate a cost effective and typical on-premise enterprise storage solution.

Block
Block storage offers greater storage efficiency (more efficient use of available storage hardware) and faster performance than traditional file storage. It achieves this by breaking a file into equally sized chunks (or blocks) of data and then storing each block separately under a unique address. Block storage is typically used in the cloud for SSDs (solid state drives) attached to virtual machines. Using Block means we can recreate a ‘standalone’ workflow by transferring a project or file to the virtual machine, potentially via UDP or perhaps through a user dragging and dropping media from a piece of file storage mounted on the virtual machine. Users edit locally on the virtual machine direct-attached storage. This process is the quickest way to get users editing in the cloud with minimal cloud
architecting needed—however, much like on-premise, this way of working is not scalable, and could quickly result in data silos.

Object
Object storage sections data into distinct units (objects). Each object has a small amount of technical metadata and a unique identifier. Object storage tends to be used to store large amounts of unstructured data and is typically used in the media industry for archiving or backing up assets. That means in practice that without a third party to simulate the structure of data in object storage, it is not a useful tier for cloud production, as it can’t be browsed or searched in the same way creatives are used to when accessing their WIP (work in progress) storage on-premise. Additionally, the read and write speeds from Object Storage for editing are not efficient. For this reason, it’s best to consider Object storage as an archive or tier 2 that you dip into to retrieve assets, rather than as WIP storage.

File
File storage is a hierarchical storage methodology used to organize and store data; data is stored in files, the files are organized in folders, and the folders are in turn organized under a hierarchy of directories and subdirectories. File storage is available in the cloud at varying IOPS ratings; typically, a higher tier of file storage will have sufficient performance for storing and editing a project and, unlike Object storage, can be mounted on the virtual machine and browsed in the kind of file-based structure an editor will be familiar with using. Effectively, file storage can be used to recreate a NAS (Network Attached Storage)-style storage ‘feel ‘in the cloud’, but the downside is the cost to store a large amount of data in the cloud with sufficient read / write speeds under this approach.

If looking to deploy VDI in multiple datacenters to 10s of users and user personas, you will need to look at how you can architect and deploy VDI in a way that is scalable, repeatable and robust. Therefore, a hybrid approach to storage is required for enterprises looking to wholly move media production to the cloud.

Ingest
There are a number of ways businesses can get assets into the cloud, depending on what applications or workflows are currently in place and how much data needs to be in the cloud. If it is decided that all on-premise media needs to be replicated in the cloud, for instance, then it might make sense to use a bulk transfer device from your cloud vendor. These are physical servers which can be deployed in your environment allowing you to utilize your on-premise storage and network to transfer media in sizeable amounts. Amazon offers AWS DataSync, an online migration tool, as well as AWS Snowball, a Petabyte scale physical media device.

However, if you are working with limited media, or on a project-by-project basis, then a UDP transfer tool will be a better option for getting the media into the cloud, as the media can then be downloaded to the local Virtual Machine or uploaded to a mounted piece of Block or File storage (see above).

Virtual Machines
A virtual machine is an emulation of a server host on a hardware server. Effectively, a new computer is created within a computer. A virtual machine (often just called a ‘VM’) runs in a window, much like any other program, giving the end user the same experience they would have on the host operating system itself. The virtual machine is also ‘sandboxed ‘from the rest of the system, meaning that the software inside a virtual machine can’t escape or tamper with the main computer or environment.
Multiple VMs can run simultaneously on the same physical computer. For servers, the multiple operating systems run side by side with a Hypervisor to manage them, while desktop computers typically employ one operating system to run the other operating systems within its program windows. Each virtual machine provides its own virtual hardware, including CPUs, memory, hard drives, network interfaces and other devices. The virtual hardware is then mapped to the real hardware on the physical machine, saving costs by reducing the need for physical hardware systems as well as obviating the associated maintenance costs that go with it, plus it also reduces overall IT power and cooling demand.

To achieve an editing experience comparable to on-premise editing, an equivalent workstation in the cloud needs to be provisioned, including CPU cores, RAM, Graphics cards. Luckily, many cloud providers have servers available to use that are not only comparable, but exceed the specifications of many expensive on-premise workstations. Amazon provides a large variety of VM instance types with different hardware specifications. The instance types tested for this guide are detailed later.

**Deploying at scale**

If looking to deploy VDI in multiple data centers and more than tens of users and user personas then you will need to look at how you can architect and deploy VDI in a way that is scalable, repeatable and robust. This section takes a high-level look at some of the additional tools and considerations needed when deploying at scale.

**Infrastructure as Code**

The deployment of virtual desktops can be time consuming. Building VDI or a cloud-powered end-user computing platform consists of multiple moving parts and components. For small scale usage, it can often be easier to work directly with a managed service provider but for enterprise clients looking to deploy at scale and manage their deployments internally, users need to look at ways in which they can template the deployment of both the underlying cloud infrastructure and the applications.

At the heart of deploying the provision of cloud services is the concept of infrastructure as code. Making the shift from point-and-click to code-led deployments allows the enterprises to much better manage and address concerns around scale, a heterogeneous computing context and efficiency. The codification of infrastructure also means an operator can take a programmatic approach to provisioning, and not only remove reliance on error-prone manual practices, in addition it provides a repeatable workflow that delivers consistency, logging, auditing and versioning to help the business gain better insight into the exact and current state of their infrastructure.

Automation by Infrastructure as code provides the following benefits:

- A high level of automation to create optimized infrastructure direct from source code
- Utilization of the pipeline architecture to allow for in-depth testing and review of code before deploying infrastructure
- Built-in approval processes which can allow for builds to be approved by an engineer before building - this can allow for the requester to simply input what they want, and the engineer just has to review and approve
Infrastructure as code also enables repeatable workflows—and by its very nature prevents runtime issues caused by configuration drift or missing dependencies.

**Group User Management**
When deploying at scale it is vital to move away from a one-to-one relationship between client and virtual machine, and start moving toward group management, allowing VM resources to be dynamically allocated. Additionally, deploying at scale means having to cater for multiple user personas... from editors, VFX artist to producers... and where a high-powered GPU machine with pixel-for-pixel representation might be appropriate for a creative, it might be simply overkill for a producer. Therefore, a business might decide an orchestration layer is needed to manage a mix of Teradici and cloud providers managed service solution.

Careful virtual machine management and group policies are vital for not only ensuring cloud cost control but also user experience. Another area of consideration is user profiles; when a user logs into a virtual machine it is vital they have a consistent experience regardless of location, ensuring that the right storage is mounted, the desktop and toolbar is in their preferred layout, and their Adobe preferences are present. Storing, managing and orchestrating these profiles are vital when deploying at scale.

**High Availability**
When deploying at a global scale, user experience is key; regardless of the applications they are using, if a machine fails the user needs to be able to log back on and continue working ASAP. To achieve this, redundancy and high availability needs to be architected into every area of the cloud deployment, from ensuring there are multiple virtual machines of the same specification available at any one time to access, to a secondary cloud broker.

To ensure this, cloud vendors give businesses SLAs and the option to buy reserved instances of any of their infrastructure. (Reserved instances is the reservation of resources in an availability zone for a set period of time, often 1 to 3 years.) In exchange for this commitment, cloud vendors reduce the hourly cost and give preferred access to these resources, guaranteeing you high availability and uptime.

**Tested Configurations**
While developing this guide, Adobe and Amazon selected AWS configurations to meet the needs of three typical user personas: News/Sports, Creative, and Promo. Separate VDI instance types and storage options were chosen to support the needs of each persona. Although testing was not exhaustive, testers verified that typical workflows and content for each persona could be performed without issue using the targeted tools in the VDI and that media played back without dropped frames.

The full range of AWS G4 EC2 instances can be found [here](#). Note that a “VCPU” is equivalent to one half of a core in a hyperthreaded physical workstation. (i.e. one physical core is roughly equal to two VCPUs in terms of processing power).
User Personas

News / Sports / Simple Edits
As the name implies, this user creates very simple edits. Content is typically two video layers and lower third. Common effects include quick color correction, scale/transform and speed. Content makes heavy use of still images (PNG and JPEG).

Tested footage type: 1080i60
Tested codec: XDCAM-50
Tested applications: Premiere Pro (primary), Audition
Estimated disk bandwidth (IOPS) required per simultaneous user: 170 Mbps
Tested AWS EC2 Instance type: g4dn.2xlarge

Creative
This user has a typical Adobe creative workflow centered around Premiere Pro, where any Creative Cloud app may be used in the creative process. A typical timeline contains 2 video, 2 graphic, and 4-8 audio tracks.

Tested footage type: 1080i60 and UHD60i (3840x2160)
Tested codec: DNxHD 145 and DNxHR SQ
Tested applications: Premiere Pro (primary), After Effects, Audition, Photoshop, Illustrator
Estimated disk bandwidth (IOPS) required per simultaneous user: 158 Mbps / 295 Mbps
Tested AWS EC2 Instance type: g4dn.4xlarge

Promos
This group creates graphics for other groups within the organization using brand guidelines created by Marketing. This group typically need the most expensive systems by far, as render times are critical. They are mostly creating in After Effects, using high fidelity codecs that are designed for compositing, not real-time playback.

Tested footage type: 1080i60 and UHD60i (3840x2160)
Tested codec: ProRes 422 HQ, ProRes 4444
Tested applications: After Effects (primary), Photoshop, Illustrator
Estimated disk bandwidth (IOPS) required per simultaneous user: 1120 Mbps / 4735 Mbps.²
Tested AWS EC2 Instance type: g4dn.8xlarge.³

² Note that real-time playback of multiple streams of this footage, especially at UHD, would require a custom storage solution that is beyond the scope of this guide.

³ Users with especially complex After Effects compositions should consider g4dn.16xlarge instances for faster render times. When optimizing After Effects render performance, CPU Clock Speed and amount of RAM are often the most important factors to consider. GPU capabilities and number of VCPUs are less important in most After Effects configurations. Conversely, a g4dn.4xlarge or g4dn.2xlarge instance may suffice for other users.
Tested Configuration Details

Common configuration
Operating System
Microsoft Windows Server 2019 Datacenter version 1809, OS Build 17763.1098

Drivers
NVIDIA Tesla T4 Driver 441.66
Teradici PCoIP Graphics Agent 20.01.1

Application Software (within VDI)
Adobe After Effects 17.0.5
Adobe Audition 13.0.4
Adobe Creative Cloud Desktop 5.1.0.407
Adobe Illustrator 24.1.1
Adobe Media Encoder 14.0.4
Adobe Photoshop 21.1.1
Adobe Premiere Pro 14.0.4

PCoIP Client Software
Teradici PCoIP Client 20.01.0

Installing Creative Cloud on Windows Server
At the time of this writing, Adobe has not certified Windows Server as a supported operating system for Creative Cloud applications. Since Windows 10 is not part of any standard AWS EC2 offerings, however, all testing for this guide was performed with Windows Server 2019. Within the limits of testing for the guide, the only issues that were encountered were related to internet security settings.

Before installing the Creative Cloud Desktop application, you must disable “IE Enhanced Security Configuration” from the “Local Server” pane in the “Server Manager” app. If you disable the config for admin users only, then you should use the “Run as administrator” option when launching the CC Desktop Installer. If you are able to sign into Creative Cloud via a web browser, but the CC Desktop Installer says it is unable to connect to the internet, try using the alternative installer found here.

Additionally, you will need to add the following websites to the Internet Explorer “Trusted sites” list for or certain Adobe licensing and feature screens to render:

- https://*.adobe.com
- https://*.adobecscstatic.com
- https://*.adobe.io
- https://*.adobelogin.com
- https://*.adobeoobe.com
- https://*.creativecloud.com
- https://*.typelkit.net

A more exhaustive list of sites to trust for Adobe products can be found here.

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4 Based on Windows Server 2019 with Desktop Experience AMI
Cache, Scratch Disk, and other application settings

Performance Settings
Premiere and After Effects both offer a number of preferences and project settings to control where data is cached. The best location for these in a VDI environment will depend on your specific workflow and priorities.

For the best playback performance, you will want to store all of your media caches on the SSD/NVMe drive attached to your EC2 instance. This has a few drawbacks, however. First, the contents of this drive are erased every time you stop your instance. If you manage costs by automatically stopping instances that are idle, Premiere and/or After Effects will need to regenerate these files each time you restart the instance. This can be time consuming for large projects. If you move between multiple instances, or collaborate with other editors, the same files will need to be generated anew on each instance.

If you consistently use the same EC2 instance, you could accept the default cache settings, which will store these files on your C:\ drive. While not as fast as the NVMe drive, the C:\ drive has the advantage that its contents are not lost when the instance is stopped. As with the NVMe option, however, the files will need to be independently re-generated by each collaborator and on each VM you move to.

To guarantee that each file is only generated and/or cached once, the best option is to store them on a shared drive that is visible on all instances and to every collaborator. This requires that the shared drive is (a) writable, and (b) has the spare bandwidth (IOPS) to accommodate the additional media read and write operations.

The settings to adjust based on your chosen caching strategy are:

Premiere Pro
Preferences / Media Cache / Media Cache
Preferences / Media Cache / Media Cache Database
Project Settings / Scratch Disks / Captured Video
Project Settings / Scratch Disks / Captured Audio
Project Settings / Scratch Disks / Video Previews
Project Settings / Scratch Disks / Audio Previews

After Effects
Preferences / Media & Disk Cache / Disk Cache
Preferences / Media & Disk Cache / Conformed Media Cache / Database
Preferences / Media & Disk Cache / Conformed Media Cache / Cache
Preferences / XMP Metadata / Write XMP IDs to Files on Import

An additional preference to consider when using shared storage with Premiere Pro is Preferences / Audio / Automatic audio waveform generation. Disabling this preference may improve playback.

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5 You could work around this limitation by creating an automated solution to copy files to and from the NVMe drive when an instance is started and stopped, but that is beyond the scope of this guide.
performance from shared storage when Premiere is generating audio waveforms for any of the connected users.

Project sharing
If the same project file or Team Project must be opened on multiple systems, you will also want to override the following paths to point to a shared drive. This will prevent CC Libraries downloads and certain Motion Graphics Templates from being usable only on the system where the project was created. These two directories do not have the same performance requirements as the ones mentioned previously, and the files are generally small. If you do not have a shared, writable media drive, you may want to set these directories to a shared Creative Cloud Files, Dropbox, or similar synced file service directory.

Premiere Pro
Project Settings / Creative Cloud Library
Project Settings / Motion Graphics Template Media

Finally, when playing UHD or other greater-than-HD-resolution media in Premiere Pro, set the Source and Program monitors to play back at ½ size or less to avoid dropped frames during playback (this is the default for these resolutions).

Tested Persona Configurations

News/Sports/Simple Edits
The workflow for this persona was tested on an AWS EC2 g4dn.2xlarge instance, with media on an S3 bucket accessed via AWS Storage Gateway. The Storage Gateway is a relatively inexpensive shared storage option and provides sufficient bandwidth to support a small number of users simultaneously playing HD footage compressed with a codec such as the tested XDCAM-50.

Only one user at a time may write to a Storage Gateway, so it should be mounted as read-only by everyone but the system administrator. For larger numbers of users or larger media, AWS FSx, a third-party media service, or a more complex solution will be required.

The g4dn.2xlarge instance has 8 VCPUs (equivalent to 4 physical cores), 32 GB of RAM, and a single NVIDIA T4 GPU.

Creative
The workflow for this persona was tested on an AWS EC2 g4dn.4xlarge instance, with media stored on an AWS FSx share to accommodate playing multiple streams of UHD footage without dropped frames.

The g4dn.4xlarge instance has 16 VCPUs (equivalent to 8 physical cores), 64 GB of RAM, and a single NVIDIA T4 GPU.

Promo
The workflow for this persona was tested on an AWS EC2 g4dn.8xlarge instance, with media stored on an AWS FSx share to accommodate fast access to multiple streams of lightly compressed UHD footage for compositing.
The g4dn.8xlarge instance has 32 VCPUs (equivalent to 16 physical cores), 128 GB of RAM, and a single NVIDIA T4 GPU.

AWS Storage Offerings

Amazon Elastic Block Store (EBS)
The Amazon EC2 g4dn instance type detailed in this document provides 2 options for block storage, Amazon Elastic Block Store (EBS) volumes and up to 1.8 TiB of direct-attached NVMe storage using the EC2 instance store. Amazon EBS provides support for boot volumes and persistent direct-attached volumes, while the instance store is ephemeral.

The g4dn instance store is a viable option for low latency ‘scratch disk’ use cases such as the Premiere Pro media cache. The instance store NVMe should not be used to store assets or project metadata requiring data protection. The instance store is local to the EC2 host system and can persist reboots of the VDI image. If the EC2 VDI image is stopped or terminated, data on the local instance store is lost. It is best practice to build a workflow where VDI instances are stopped when not in use, thereby controlling the billing costs associated with hourly usage.

The g4dn VDI instance type supports between 3.5 GB/s and 19 GB/s data throughput from EBS volumes, depending on the instance size. An EBS volume is protected against the failure of any single component and designed for 99.999% availability. Because EBS volumes are inherently redundant, throughput exceeding 1 GB/s per volume is only possible by creating software RAID 0 groups of EBS volumes in the Windows Disk Management utility. While the underlying EBS volumes are protected from data loss due to a single component failure, the RAID 0 volume is still subject to data loss due to human error if a single EBS volume is removed or deleted.

AWS FSx for Windows File Server
The Amazon FSx storage services are a family of fully managed 3rd party file systems offering standardized compatibility with host operating systems, applications, and workflows, and deep integration with other AWS services like S3. AWS FSx for Windows File Server is a storage service with a truly native Windows (Server Message Block) SMB protocol implementation. FSx for Windows File Server supports the same features and management tools as a self-managed Windows File server, but fully automates the server hardware and software configuration, file server deployment, Microsoft Windows updates, and file system backup tasks. FSx for Windows integrates natively with AppStream 2.0, Amazon WorkSpaces, AWS IAM, AWS Directory Service for Microsoft Active Directory, AWS KMS, AWS CloudTrail, and other AWS Services. FSx for Windows supports automated and manual file system backups that are protected at a service-level by S3.

Because FSX for Windows File Server is a native Windows File Server SMB protocol implementation, performance-enhancing features like server-side copy, client-side caching, Distributed File System (DFS), and SMB Multichannel are inherently compatible with existing applications and workflows.

FSx for Windows File server is the easiest and most reliable method for attaching a volume capable of delivering over 2 GB/s throughput to a single VDI instances. FSx for Windows File server support both
SSD and HDD based volumes. SSD volumes are preferred for low-latency, high-throughput use cases such as 4K post-production or collaborative multi-user workflows. HDD volumes are suitable for non-4K workflows that do not require sub-millisecond latency or high throughput. As an example, workgroups of editors using the New/Edit/Sports profile detailed in this document should consider the SSD volume option for workgroups of 12 or more concurrent editors.

FSx for Windows decouples storage caching and throughput performance requirements from the usable capacity of a volume. With a traditional self-managed storage server, you need to allocate adequate storage capacity to meet your throughput requirements. When provisioning an FSx for Windows volume, you have the option to provision up to 2 GB/s of network IO and cache per volume regardless of the provisioned storage capacity.

FSx for Windows requires Microsoft Distributed File System Namespaces (DFSN) to scale capacity beyond 64 TiB in a single namespace as capacity requirements grow. Similarly, workflows requiring more than 2 GB/s throughput per namespace must use DFSN to scale aggregate throughput as the workflow and bandwidth requirements grow. A good rule of thumb for organizations that require more than 64 TiB in a single namespace is to plan for a single FSX for Windows per volume per project. In some larger workflows, the capacity and bandwidth requirements for a single project are more predictable than the aggregate of all projects across multiple project timelines. When designing a workflow for operational efficiency, one must consider the factors used in billing for cloud storage. By allocating a volume per project, per project, or some other logical division, you have a mechanism to allow granular tagging of the volume for cost-tracking.

The monthly cost for FSx for Windows depends on the following factors:

- Capacity: The monthly cost per GB of active HDD or SSD volumes.
  - Avoid paying for excess unused space when provisioning FSx for Windows volumes. When choosing between a single AZ and redundant AZ deployments,
consider the overall cost to your business if all data from the last recovery point is lost. Also, consider the time required to restore content from S3.

- **Throughput:** The monthly cost of provisioned in-memory cache and MB/s throughput.
  - Avoid paying for excess bandwidth by starting small, monitoring performance via AWS CloudWatch, and provisioning new FSx for Windows volumes from backups when additional throughput is required.

- **Backups:** The monthly cost to snapshot backups of your filesystem.
  - Retaining backups is far less expensive than keeping an FSx volume on-line after the production or project is complete.

At the time of this writing, the HDD tier of FSx for Windows is the lowest cost storage option for Windows in a public cloud. The trade-off for this low cost is performance. The FSx for Windows SSD tier adds 750 MB/s of baseline throughput for every 1 TiB of provisioned capacity. In contrast, the HDD tier adds 12 MB/s of baseline throughput per 1 TiB of provisioned capacity. The maximum possible baseline throughput for an HDD tier volume is 768 MB/s at 64 TiB. The baseline performance of FSx for Windows volumes is fundamental when comparing the payback performance across multiple concurrent SMB connected workstations. Certain operations, such as scrubbing a preview clip, can benefit from the additional throughput performance provided by both client-side caching and additional server-side in-memory cache. Baseline throughput performance is a critical consideration when planning the throughput requirements for multiple concurrent clients playing long Premiere Pro sequences, thereby negating the otherwise beneficial effects of caching frequently read files. The worst-case-scenario of all connected editors playing entire sequences from the in point to the out point is an all-too-common occurrence at the end the business day. For more information about provisioning baseline throughput, network I/O, and cache capacity, please visit Amazon FSx for Windows File Server Performance.

Amazon Simple Storage Service (S3)
Amazon S3 is the object storage foundation for the 'content lake' in end-to-end media workflows. S3 is the storage of choice for media ingested into AWS and the hub for broadcast and post-production workflow spanning a wide array of applications. The S3 object storage API is common to native AWS services like the Artificial Intelligence/Machine Learning services Amazon Rekognition, Amazon Transcribe, and Amazon Sagemaker and AWS Elemental Media Services. Content ingested into Amazon S3 can be exposed to the broadest and most in-depth selection of services for transcoding, MAM, collaboration, and archive available in any public cloud.

The number of options moving content in and out of Amazon S3 can be dizzying. Media file transfer utilities, review/approval Software as a Service (SaaS) offerings, and archive management tools with direct integration to both Amazon S3 and Adobe Premiere Pro can accelerate the movement of data in and out of S3 from on-prem and in the cloud. For more information and help building a solution, please contact an AWS Media and Entertainment Specialist or one of the Systems Integration Services Providers listed below.

AWS Marketplace Storage Offerings
The AWS Marketplace has cloud-native and hybrid cloud storage options that address a wide array of workflow concerns. Post-production workgroups using Qumulo File System (QFS) on-premises can leverage self-managed Qumulo storage instances in the VPCs supporting their Adobe Creative Cloud...
workstations for emergency or ad-hoc workflows. QFS simplifies the deployment of a hybrid-cloud post-production workflow in 3 ways:

i. Quick and easy deployment of a self-managed QFS NAS cluster from the AWS Marketplace by using an AWS Cloudformation template.

ii. For customers running QFS scale-out NAS clusters on-premises, Qumulo continuous one-way provides a simple method for replicating content to the cloud for ‘cloud-burst’ workflows.

Organizations requiring hundreds of TiB or PiB of capacity in a single cloud-based filesystem can linearly scale-out throughput and capacity by adding additional server nodes to the QFS cluster.

Security
AWS offers virtual private cloud security group acting as a virtual firewall for your instance to control inbound and outbound traffic. When you launch an instance in a virtual private cloud, you can assign up to five (5) security groups to the instance. Security groups act at the instance level, not the subnet level. Therefore, each instance in a subnet in your VPC can be assigned to a different set of security groups.

Limiting the access to your Teradici hosts is best to be done on a subnet or IP basis. That same security group can be attached to each of the edit in the cloud hosts, and easily updated instantly. This will add a consistent access posture for your end users.

VPN
Client based connectivity can come in many flavors, and types. That can range from an office setting, home, or even mobile. With security as a focus there are options to prevent access to your AWS resources.

If the connection originates from a corporate office or field location, a site-to-site VPN can be optimal for a one-to-many connection. With AWS Site-to-Site VPN, you can connect to an Amazon VPC in the cloud the same way you connect to your on-premises locations. AWS Site-to-Site VPN establishes secure and private sessions with IP Security (IPSec) and Transport Layer Security (TLS) tunnels.

If the users are mobile, or leveraging their home internet connection, a VPN client software can be used. AWS Client VPN is a fully managed client-based VPN service which automatically handles the deployment, capacity provisioning, and service updates. With AWS Client VPN you can monitor and manage all your connections from a single console.

Enhanced Networking
The Amazon EC2 g4dn instance family uses the current generation of Enhanced networking interfaces from AWS. Enhanced networking is a single root I/O virtualization (SR-IOV) implementation that increases network bandwidth, improves packet per second (PPS) performance, and reduces latency between instances. The Windows Server 2019 Desktop Experience Amazon Machine Images (AMI)s used in this solution are preconfigured to use network checksum offload and Receive Side Scaling (RSS) which parallelizes network traffic processing over multiple CPU cores. The g4dn instance sizes detailed in this guide use 25 or 50 Gigabit network interfaces.

Licensing Considerations
VDI
Teradici PCoIP offers per-user annual licenses with unlimited usage. At the time of this writing, the Cloud Access+ offering is most appropriate for the tested configurations.

As an alternative, AWS Marketplace images are also available that include a pay-per-use PCoIP license. These do not require an advance purchase or commitment but can exceed the annual license cost if used heavily.

Adobe CC
Each VDI user must have a valid Adobe ID and Creative Cloud license.

Third-Party Fonts
Check with font vendor about running in the cloud

Plugins
Check with your plug-in vendor about running in the cloud

Cloud Broker software
Teradici Cloud Access Manager license is included with PCoIP license. Leostream charges a separate, annual, per-user license.

Third Party Workflow Solution Providers
There are many options to consider when setting up a VDI environment. The simplest is to start with a Marketplace image from Amazon and install Creative Cloud and other components manually. Larger enterprises often require more complex solutions. Below are a number of well-respected companies that can help create or be part of the best solution for your company.

Bespoke Solutions / Systems Integration
AWS – Media and Entertainment Specialists
Moov-IT
Qvest Media Cloud
Support Partners

Fully Configured Cloud Production Services
BeBop
StratusCore

Collaboration/Review & Approval
Frame.IO
Helmut
Lookat.io
Wipster

Shared Cloud Storage
EditShare
Adobe's Partners are not limited to the companies listed in the above section. See the Adobe Video & Audio Partner Finder for additional third party solutions.

References
Adobe Team Projects
Adobe Technical Support boundaries for virtualized and/or server-based based environments
Adobe Video & Audio Partner Finder
Amazon FSx for Windows File Server Performance
AWS EC2 G4 Instance Types
Creative Cloud Product description and limitations
Creative Cloud Terms of use
NVIDIA Enterprise Support
Using Proxies in Premiere Pro
Teradici Cloud Access+
Teradici Cloud Access Manager datasheet
Teradici PCoIP Firewall Settings
Teradici PCoIP Protocol Virtual Desktop Network Design Checklist

Glossary
Active Directory (AD) - allows network administrators to create and manage domains, users, and objects within a network

Amazon Machine Image (AMI) - The pre-configured operating system image used to deploy an Amazon EC2 server instance. AMIs are tracked by an AMI identification number that is routinely updated as the images are updated with current hotfixes and patches.
Bandwidth - refers to the capacity of data a network is capable of transferring from one point to another.

Connection Broker - a resource manager that manages a pool of connections to connection-based resources such as databases or remote desktops.

Egress - The act of moving data out of the

Instance - a virtual server instance from a public or private cloud network.

IOPS - Input/output operations per second is an input/output performance measurement for computer storage.

Jitter - Jitter in IP networks is the variation in the latency on a packet flow between two systems.

Latency - the delay between data being sent and the action.

M&E - Media and Entertainment Industry.

MAM - Media Asset Management, a system for accessing and managing assets.

Mbps - Megabits per second (Mbps) are a unit of measurement for bandwidth and throughput on a network.

MFA - Multi-Factor Authentication is an authentication method in which a computer user is granted access only after successfully presenting two or more pieces of evidence.

NDI - Network Device Interface protocol to enable devices communicate, deliver, and receive broadcast quality video in a high quality, low latency manner.

PCoIP - PC over IP is a remote display protocol that Teradici developed for delivering remote desktops and applications to endpoints.

Region - Regions are geographic locations in which public cloud service providers' data centers reside.

SDK - Software Development Kit.

SRT - Secure Reliable Transport is an open source video transport protocol that optimizes video streaming performance.

Thin Client - a computer with minimal compute and flash memory used to access VDI.

VCPU - Virtual central processing unit.

VDI - Virtual Desktop Infrastructure.
VGPU - Virtual graphics processing unit

VM - Virtual Machine

WIP - Work in Progress, used in this document to refer to tier 1 storage

Zero Client - a computing device has no local storage

ROI - Return of Investment

TCO - Total Cost of Ownership

Datacenter - a large group of networked computer servers used for the remote storage, processing, or distribution of large amounts of data.

QoS - Quality of Service

TCP - Transmission Control Protocol is a standard that defines how to establish and maintain a network conversation

UDP - User Datagram Protocol used for establishing low-latency and loss-tolerating connections between applications on the internet

WRED - Weighted random early detection is a queueing discipline for a network scheduler suited for congestion avoidance

About Support Partners
Support Partners is the media industry’s leading cloud specialist, helping to design, deploy and support innovation in the cloud. With over 15 years’ experience supporting and guiding the world’s largest media organizations in Broadcast, Advertising, Publishing, Sports and Post-production, we know what it takes to accelerate innovation in media production. We also work closely with the world’s leading technology platforms to transform how media is created, stored and distributed: go to https://www.support-partners.com to find out more.

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