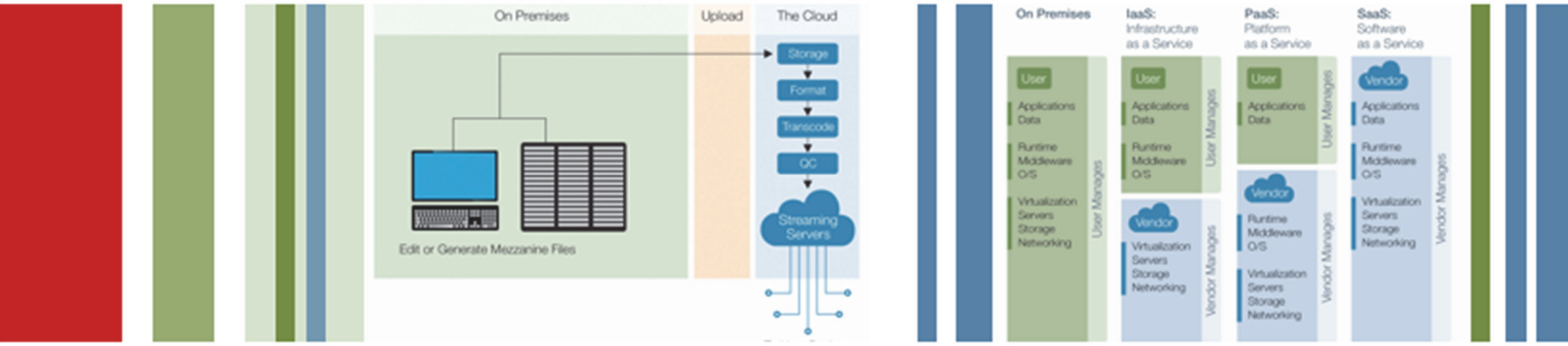

Cloud Computing for Video Workflows

Technical Brief

What is covered:

- Changes Driving Use to the Cloud
- Characteristics of Cloud Computing
- Cloud Architecture
- Cloud-based Service Models
- Cloud-based Video Workflow
- Glossary of Terms

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Introduction

The term “cloud computing” has been around for years, but only recently has the cloud begun to play a role in the video workflow. It is a concept that video producers, distributors, and technologists must grasp in order to remain competitive in the future.

The cloud is a metaphor for a network made up of many computers interconnected and working together via a real-time communication infrastructure. In theory this implies any large aggregation of inter-working computers, but in practical terms it means the Internet.

The cloud icon, though not a true schematic symbol like a resistor or a logic gate, is the *de facto* standard visual representation of the Internet in network topology diagrams.

While millions of hardware servers are at the Internet’s heart, the moment-to-moment connectivity and load-sharing is variable and invisible to the end-user. In effect the cloud deploys all this hardware as virtual servers that can move and scale in real time to meet instantaneous demands, much as a cloud in the sky changes shape, size, and position constantly.

Why a cloud?

Because the amorphous appearance of a real cloud — opaque here, nearly transparent there, with indistinct edges and gradations throughout — suggests the dynamics within the Internet.

A Change Driven by Business and Technical Realities

The video industry has a long tradition of subcontracting specific tasks to external service providers such as post-production houses. Until recently the process has involved sending tangible media—tapes or disks—to the contractor by courier, or by FTP transfers between computers in the early days of file-based video.

This arrangement was an accepted part of the workflow but its efficiency was hampered by the time and cost of the transfers and by a lack of elasticity—the ability adapt to varying workloads. The need to address proliferating output formats and platforms has further complicated the operation of this model.

The industry is Looking for Solutions

The cloud offers a new way to manage video content. Cloud computing can deliver cost and efficiency benefits that outpace in-plant hosting approaches:

Convert Costs from Capital Expenses to Scalable Operational Expenses	Centralize the Infrastructure to Support Functions (i.e., QC, Transcoding, Storage)
▪ This reduces the cost of entering or growing a video business. − Rather than buying a facility full of expensive equipment, users “rent” the needed infrastructure from a provider of hosting and computing services. ▪ The package comes as a “pay-as-you-go” offering predictable costs from month to month. ▪ The service comes with reliability guarantees and the IT experts to ensure them. − The service vendor has backup and disaster recovery resources to protect valuable content. − The vendor provides floor space, cooling, maintenance, security, and other necessities. ▪ The video enterprise can concentrate on its core business.	▪ Everything resides in a contiguous environment from the customer’s perspective. − Just as though it was housed in a proprietary data center. ▪ Transactions are faster and less costly. − A transcoding tool running on a CPU instantiation within the cloud, for example, can fetch a file from a “local” library, also within the cloud.

A Change Driven by Business and Technical Realities

The cloud vendor's profit model relies on the efficiencies of on-demand usage and shared resources. The vendor's overall capacity is huge, but the "excess" doesn't languish; instead it gets dynamically assigned to another task or another customer.

Contrast that with an in-house facility that must be designed with the headroom to handle worst-case loads, even though much of that capacity is often dormant. Figure 1 depicts the cloud from the video enterprise's perspective.

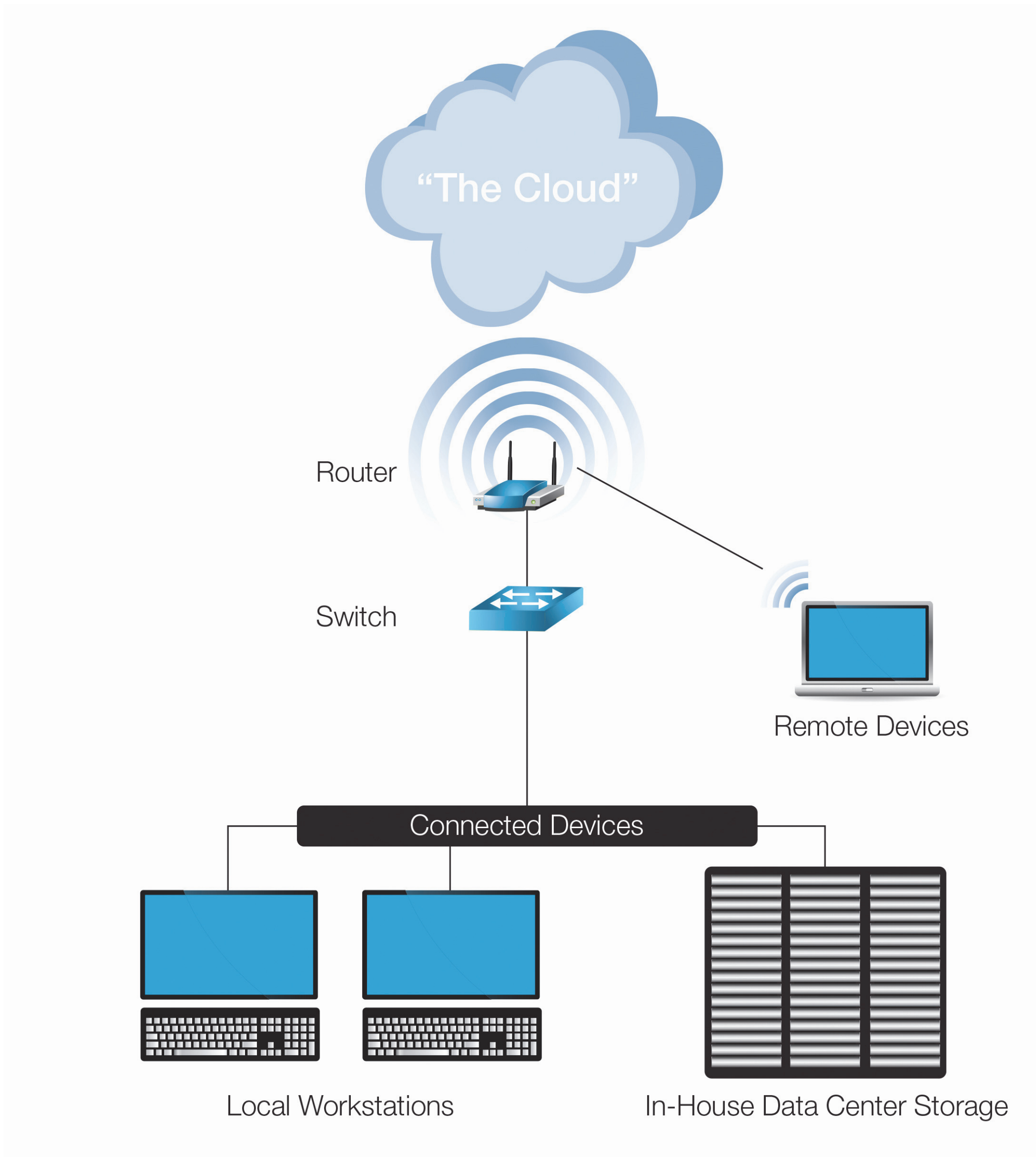

Figure 1. The cloud offers a scalable environment that can reduce the on-premises computing and storage burden.

Characteristics of Cloud Computing

While this discussion pertains to the needs of the video workflow, keep in mind that the cloud is a general-purpose entity. But the underlying business and technical characteristics of cloud computing are a good match for the needs of video enterprises that must manage costs while delivering uncompromised service to subscribers.

The enabling features include:

- On-demand Self-service
- Broad network access
- Resource Pooling
- Rapid Elasticity
- “Metered” Service

Self-service Access to a broad range of cloud-based tools ensures efficiency and responsiveness in the relationship between user (the video enterprise) and the vendor. Customers can simply log on to their account on the vendor’s web page and add or modify service levels as needed. The site acts like a vending machine from which customers order server time, storage capacity, and ultimately operating systems and software to match the needs of the moment. Similarly, they can make changes at any time. The whole transaction occurs without the need for intervention by the vendor, and the “deliverables” are available for immediate use.

Cloud computing supports **broad network access** for its customers. Solutions are offered over a variety of access interfaces and client platforms. A range of “solution stacks”—comprehensive toolsets used for developing web applications—makes it expedient to move all or part of a video workflow into the cloud.

The elements of a solution stack include the operating system, web server, database, and programming (scripting) language. Many solution stacks are built around the Linux operating system (OS); others are built on the Windows Server OS or cross-platform environments.

Resource Pooling is key to the effectiveness of the whole cloud concept. Resources, whether storage or compute capacity, are shared by multiple users. The vendor’s entire physical infrastructure supports virtual partitioning of these functions and assigns resources dynamically among many users. One customer’s CAD project might be running concurrently with another user’s video QC job, but the two will never meet. Every user always has full access to all the CPU instantiations he or she has ordered, for example, though the actual computing activity is not mapped to specific physical servers. This leads to the next cloud characteristic, namely…

Rapid Elasticity, denotes resources that can be provisioned, re-sized, and released to scale with user demand. Importantly, this “demand” is not held to some arbitrary length of time whether it is needed or not. Users can rent capacity for hours or years, as needed, and release it with impunity.

Measured Service is the means by which cloud vendors extract revenue from their cloud operations. While there is usually no upfront charge to provision a service such as a block of storage, resource usage is metered. Applications too can be measured; common video operations such as transcoding or file QC operations are usually charged by the minute of play time for the end product.

Cloud Architecture

In the “macro” view, the architecture of the cloud embodies three functional categories. Figure 2 outlines some of the important elements within these categories. Outside the cloud, devices ranging from desktop PCs to video editing systems to smart phones surround and interact with the functions therein.

It is important to understand that only the Application category is unique to the video discipline. The Infrastructure and Platform categories are general-purpose constructs. Figure 2 could be re-drawn for any application from banking to engineering, and the functions in the Infrastructure and Platform layers would remain the same.

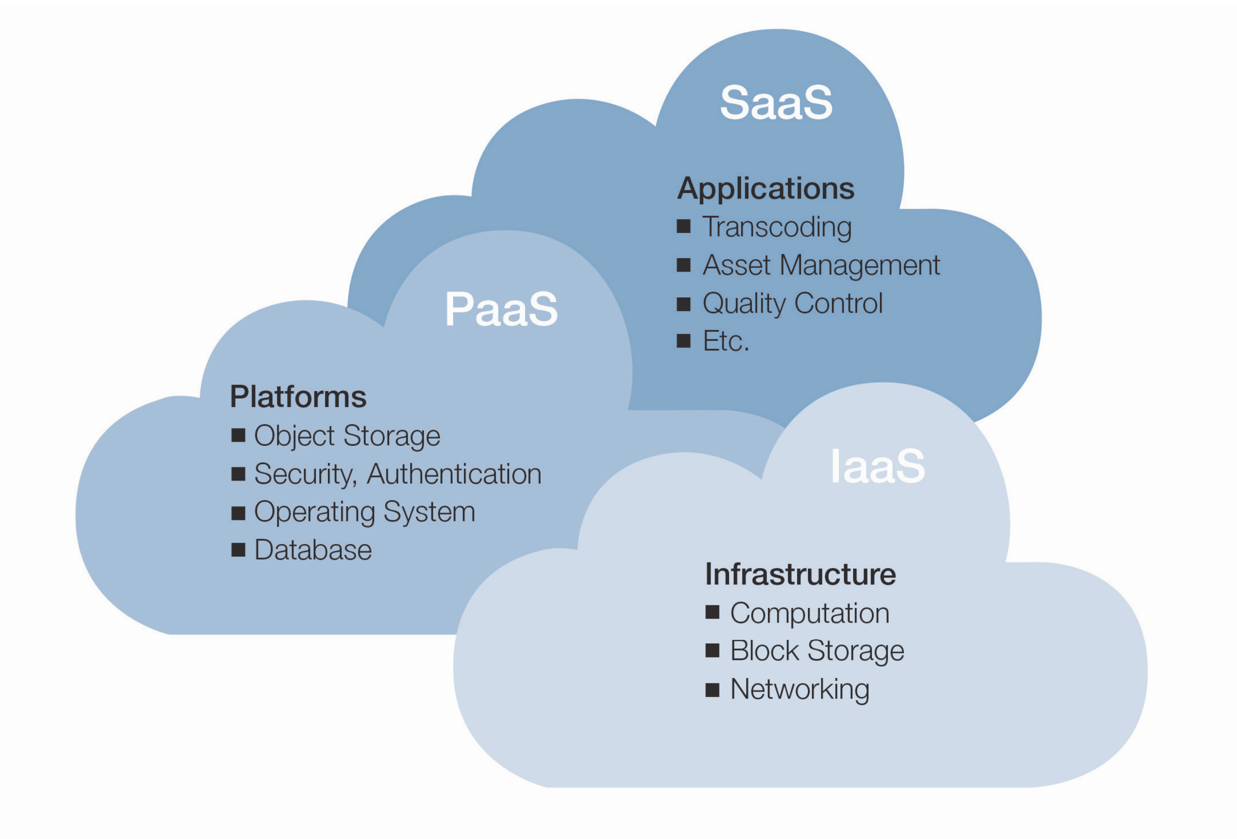

Figure 2. Three tiers of activity reside within the cloud.

Cloud-based Service Models

Cloud service providers strive to make it as easy as possible for customers to understand, select, and order cloud products. Ideally the process is as simple as ordering a book or a sweater online. While there are many specialized functions to choose from, the basic products are storage and computing capacity. Users accustomed to doing everything in-house can set up the same terabytes of disk space in the cloud. They can configure the same computing platforms and operating systems as they have used in their brick-and-mortar facility. They can send and retrieve files at the time of processing, or store the files in the cloud and perform operations like transcoding exclusively within the cloud.

Again, most video enterprises historically have performed all operations in-house using their own hardware and applications. In Figure 3, the **On Premises** column outlines the litany of steps and processes executed in a typical full-scale facility. The user supports capital costs, hardware and software maintenance, security, IT, and more.

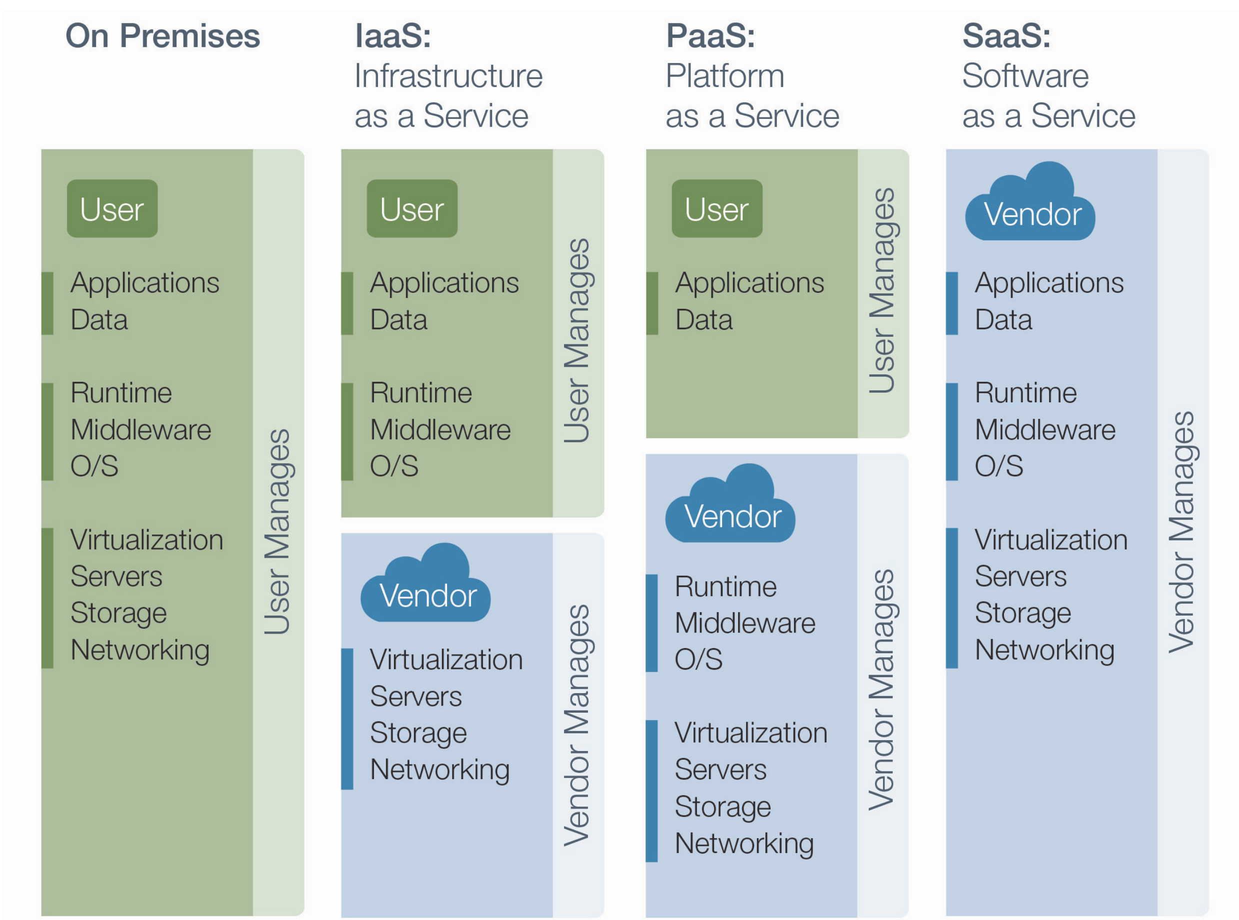

Figure 3. Successively higher service levels in the cloud allow the end user to tailor the balance between in-plant and off-premises workflow features.

The cloud services hierarchy begins with **Infrastructure as a Service (IaaS).** This is the most basic of three levels of cloud service offered in the marketplace today, providing only computing resources and storage. This service can be viewed as a means of substituting the cloud for certain on-premises hardware. IaaS is offered by major commercial vendors such as Amazon (with their EC2 virtual computer instantiations and S3 storage “buckets”) and Microsoft with its comprehensive Azure cloud service. Many users need little more than the IaaS solution. With no up-front costs and the ability to scale up or down on demand, smaller enterprises are well-positioned to grow. Larger institutions may rely on IaaS to cost-effectively handle peaks in demand while maintaining their own on-premises infrastructure for day-to-day operations.

Services in the IaaS model are billed like a utility, but instead of kilowatt hours or gallons rates are based on computing time and storage use. APIs are typically implemented with SOAP (Simple Object Access Protocol) and REST (Representational State Transfer) protocols, both of which are proven environments for exchanging information to deliver web services.

The next level up in terms of service is **Platform as a Service (PaaS).** Major IaaS providers offer PaaS as well. This level provides not only a computing platform but also a solution stack.

What is a solution stack? It is a toolset containing all the software components needed to develop a web application:

- Operating system
- Web server
- Database
- Programming language.

One of the most common solution stacks is LAMP, which embodies:

- **L**inux (operating system)
- **A**pache (web server)
- **M**ySQL (database management system)
- **P**erl, PHP, or Python (programming/scripting languages)

Another common solution stack is Microsoft’s WISA, which uses the Window Server operating system and adjunct components.

- **W**indows (operating system)
- **I**nternet Information Services (file/web server)
- **S**QL Server (database software)
- **A**SP.NET

As Figure 3 symbolizes, PaaS takes a larger share of the management responsibility out of the user’s hands. The user enterprise manages only its own applications and data. All of the supporting development tools are vendor-supported, with associated guarantees of reliability, backup, security, etc.

Software as a Service (SaaS) brings virtually everything into the cloud. In addition to the underlying storage and computing resources, on-demand software is provided by Application Service Providers (ASPs). The concept is one of centralized multi-tenant software architecture accessed by thin clients via a web browser. This is in contrast to purchased software residing on a PC or in the user's facility. Google Apps and Microsoft Office 365 are business-oriented examples of this implementation approach, which is also beginning to penetrate technical disciplines including video production and distribution. Typically the ASP charges by the minute of processed end product. Importantly, users pay only for the time used. They do not pay for the tool to stand by on a 24/7 basis.

Today a variety of cloud ASPs serve the video industry. Their services span almost every type of file processing as well as archiving and streaming delivery. A video customer is not constrained to any one provider for all processes. Most cloud ASPs can accept content either from the customer or from a designated provider in the cloud.

The Cloud-Based Video Workflow

Increasingly, cloud-based functions are taking a place in the industry as an alternative to equivalent in-plant solutions. As Figure 4 shows, all the main steps involved in delivering a video product can be handled within the cloud. The cloud "product" consists of virtual hardware functionality (CPUs and storage) plus the applications to execute the needed processes. Figure 4 is a simplified representation in which the depicted "blocks" symbolize a function, not the scale of that function.

Asset storage is an obvious candidate for cloud operations. Capacity is essentially limitless. Mezzanine files can uploaded after local ingest and editing. These files can be retrieved for further processing (with some added delay when compared to local storage) on in-house equipment if that is the chosen operating model. Better yet, they can be acquired, processed and re-stored without ever leaving the cloud. Long-term archiving is also available in the cloud. Cloud-based archiving has the compelling advantage of easy scalability while still offering reasonably efficient access to the stored content.

Many enterprises are turning to content processing in the cloud. Input and output file locations may or may not reside within the cloud, but wherever the material is stored it can be delivered to independent providers of services such as transcoding and quality control (QC). Transcoding vendors act on the customer's instructions and specifications (including optional encoding settings) and encode content simultaneously into as many formats as the user requests. The deliverables can be stored in the cloud or loaded back into the customer's on-site servers. QC operates similarly; the pay-as-you-go Tektronix QCloud toolset performs the exact same tasks and delivers the same results as the purchased Cerify solution. With QCloud the user sees a user interface on a CPU instantiation, which is the same view he or she would see on a local machine running Cerify.

Streaming delivery is equally expedient via cloud-based mechanisms. A full-service streaming vendor offers turnkey hosting plus preset and user-configurable players, developer support, analytics, and more.

These components would represent a substantial support requirement for an independent user, but the cloud architecture makes it possible to provide a cost-effective range of services to many users.

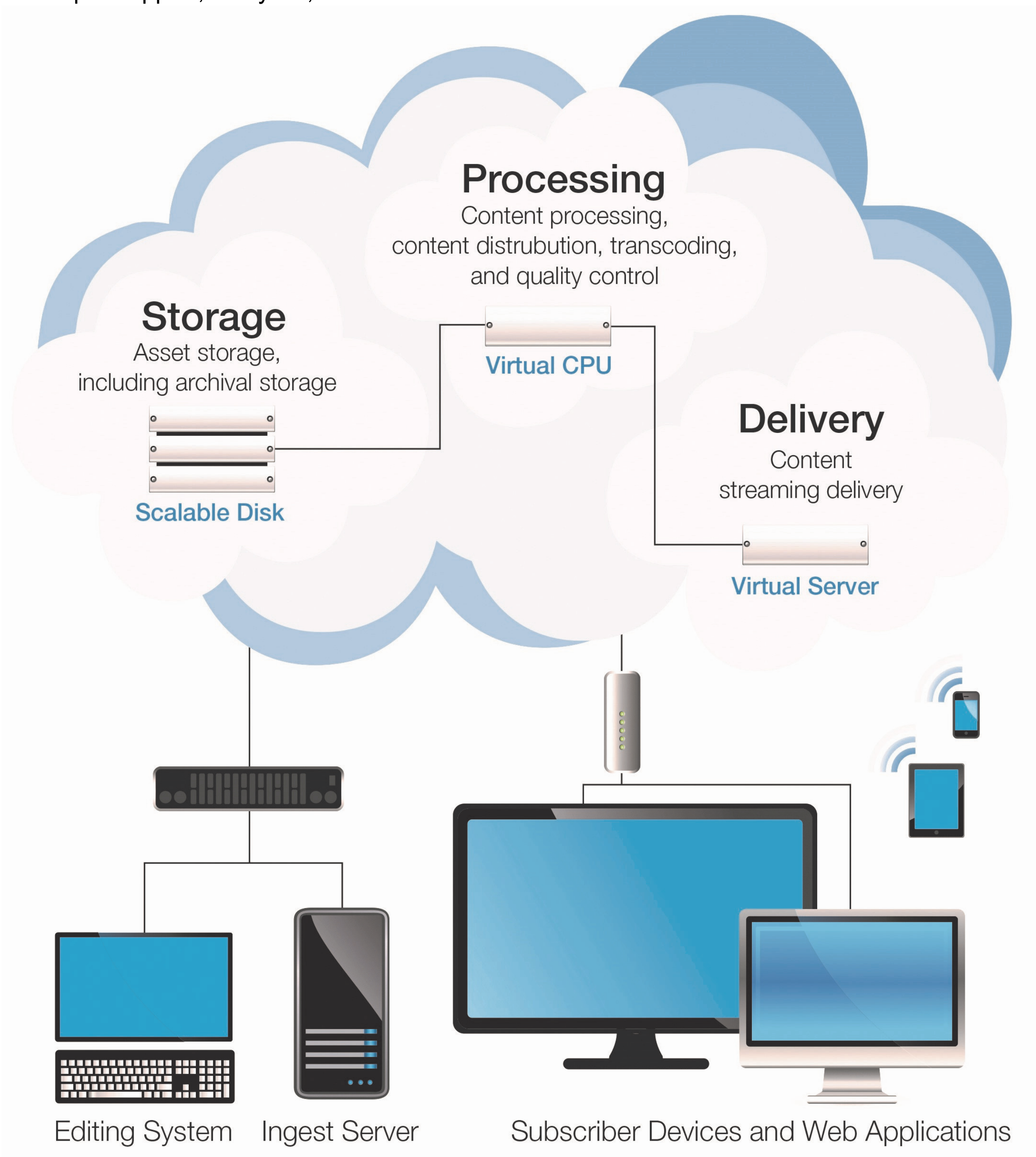

Figure 4. As more functions are brought into the cloud, the workflow gains efficiency.

Discrete cloud services like transcoding, QC and streaming video delivery are useful and valuable in their own right. Some enterprises will run just one or two of these processes within the cloud and perform the rest in-house. But the greatest benefit accrues when multiple processes are teamed up in a broad cloud-based workflow. Adaptive Bit Rate (ABR) streaming delivery is a case in point.

Streaming vendors deliver ABR video directly from the streaming server to the consumer. This last leg of content delivery is best handled by cloud infrastructure operators such as Google, Amazon, Verizon, etc. Their capacity is hard to equal in an enterprise-owned facility.

But streaming demands are complex. There is a host of streaming technologies (HTTP Live Streaming, Microsoft Smooth Streaming, etc.) whose needs must be met. Each requires its own diverse group of versions for a given piece of content. These versions have differing resolutions and different bitrates to accommodate all the target display devices and network bandwidths. It adds up to a lot of repetitive transcoding on any one piece of program material. Figure 5 is a simplified illustration of the process, with most of the steps implemented on-premises.

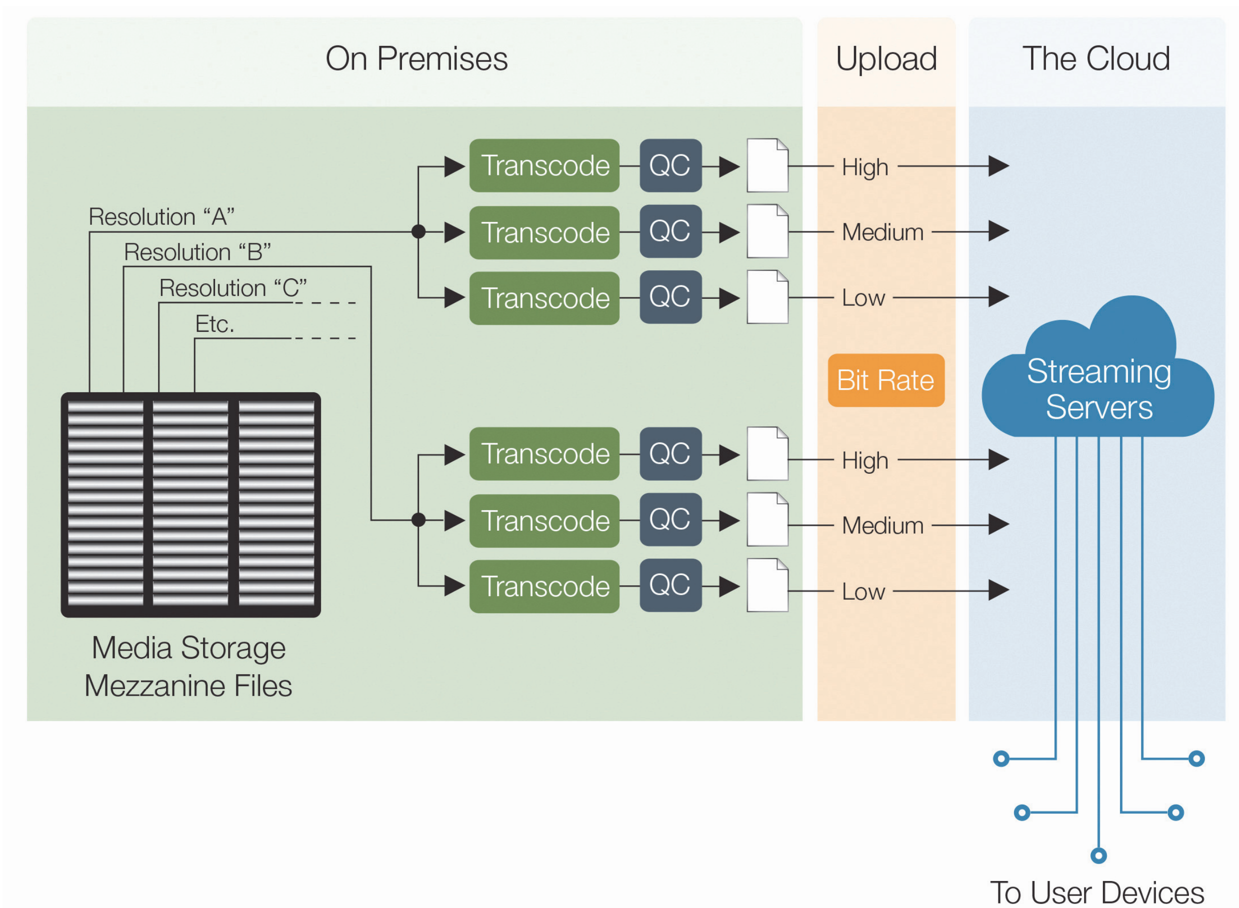

Figure 5. When the ABR workflow is contained on premises, many files must be sent individually to the cloud.

Many video companies have discovered that the most efficient approach is to upload one mezzanine file (the master) to the cloud and perform all the subsequent operations there rather than transcoding locally and uploading multiple versions. Figure 6 illustrates this alternative.

The choice is one of sending a single mezzanine file to the cloud and processing it there, or processing on premises and sending many files to the cloud. The conclusion is that streaming delivery is more efficient if most of the workflow—not just the last step—is performed in the cloud.

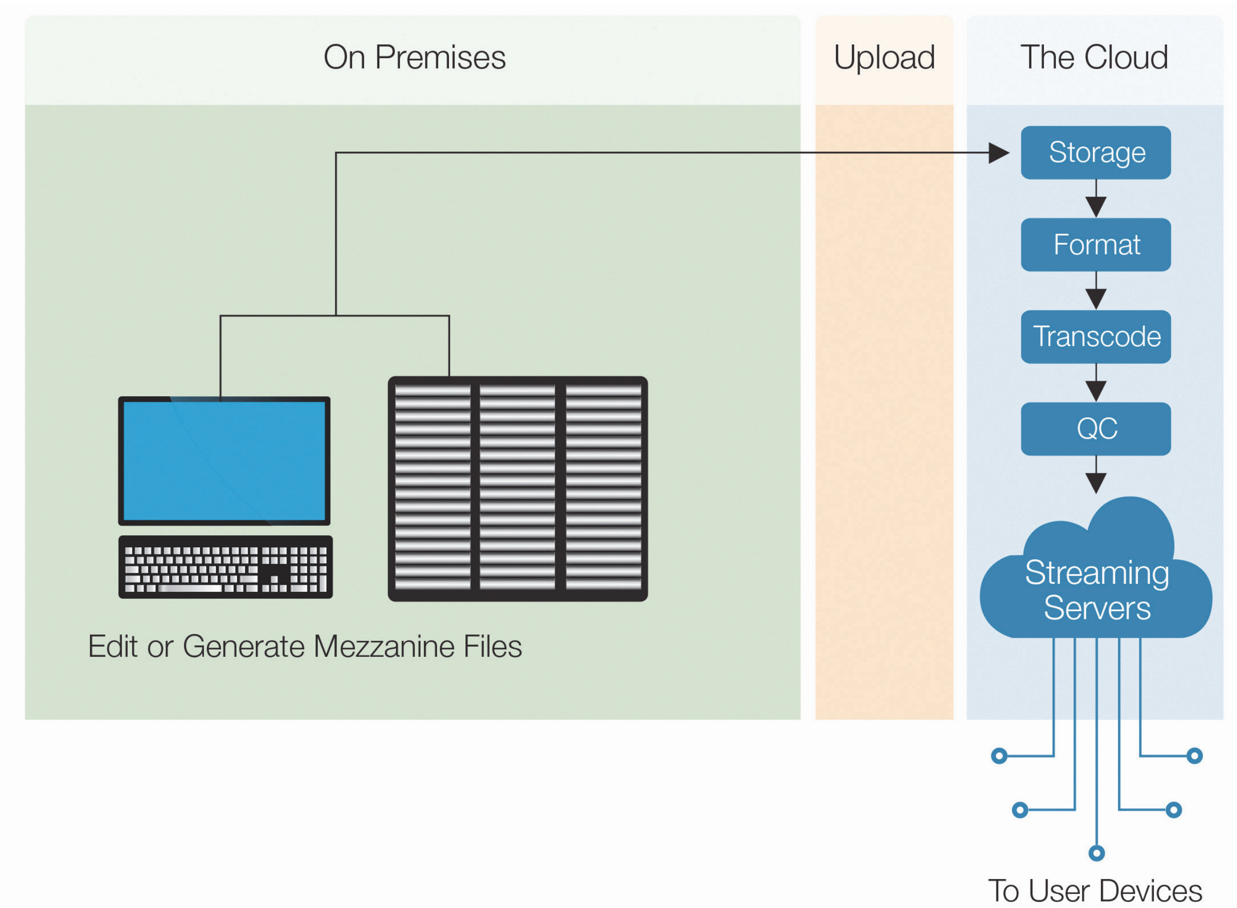

Figure 6. A cloud-based ABR workflow minimizes the traffic between the video facility and the cloud.

Thinking Inside the Cloud

This chapter opened with a claim that video enterprises are increasingly turning to cloud-based management, processing, and distribution of their video product. Consumer viewing platforms are multiplying in the market, driving a demand for more formats and as always, better quality and reliability.

Inside the cloud, the infrastructure is already in place, and constantly expanding and modernizing to support these needs.

Cloud-based processes are a ready solution to help video companies grow with their end-users' demands while reducing capital costs.

Glossary of Terms:

Cloud Computing – Internet-based services such as access to remote software applications and file storage.

Video Workflow – Sequence of operations for file-based video, from an input source such as capture or ingest to an output destination such as broadcast or delivery.

Quality Control – Process for reviewing material in order to find potential problems in the encoded video and audio or in the associated metadata.

Instantiation – Creation of a specific realization of a virtual object, such as a computer or storage system.

Self-service Access – Ability of the user to provision and create instances, without manual intervention from the service provider.

Resource Pooling – Maintaining a ready-to-use set of resources (computers and storage) that can be assigned to individual users on demand. Each pool is shared by many simultaneous users.

Rapid Elasticity – Ability to quickly and automatically add or remove resources for an existing instance, so that the instance's capacity more closely matches the current demand.

Measured Service – A cloud service (computing or storage) in which the service provider monitors the resource consumption of each user and bills them according to the actual usage.

Infrastructure as a Service (IaaS) – The most basic cloud service model, where the service provider offers computing and storage resources along with the associated network connectivity.

Platform as a Service (PaaS) – A cloud service model where the service provider offers a complete computing platform, which includes the hardware infrastructure and software components such as the operating system, programming language execution environment, database and web server.

Software as a Service (SaaS) – A cloud service model where the application software is offered by a service provider directly to the end user.

Mezzanine File – A file format used at an intermediate stage of the workflow (after ingest and before broadcast), usually with a bit rate much higher than the final playout format, but still much lower than the bitrate for uncompressed video.

Adaptive Bit Rate – A technique used to deliver streaming multimedia over a network, that can dynamically adjust the bitrate of the stream (and therefore, it's video and audio quality) to adapt to the currently available network bandwidth and processing power of the player client.

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