IBM Software
Technical Whitepaper

An integrated model for predictable, high-speed global content delivery

Empowering content distributors by streamlining and securing IT infrastructure

aspera
an IBM® company

Contents:

Highlights

Overview

Aspera empowers content distributors to consolidate their IT investments while securely delivering high-resolution media worldwide with the utmost quality of service.

Use cases

- Advanced contribution and automation
- High-volume content ingest, processing, transformation and distribution
- Ad ingest and insertion for video-on-demand
- End-to-end content preparation and distribution

Benefits

- Receive terabytes of file-based content per day from providers at even global distances with simplicity, high-speed and low cost.
- Eliminate costly re-sending of files when transfers fail with FTP, laborious monitoring, and network collapse caused by data blasters or parallel FTP streams.
- Consolidate the entire network with fewer origin servers, POPs, and edge servers, as content need not be served locally for high throughput.
- Fully automate ingest, transformation and distribution of media files with integrated transport, tracking, and management to help prevent human error, increase security, accelerate time-to-market, and reduce cost.

Introduction

We have reached a pivotal moment in videotape history. File-based workflows are here, going global, and becoming unmanageable. Content is flooding networks and people. The sheer volume of files contributed poses significant logistical and financial challenges for receiving, processing, and distribution. Suppliers are diverse, specialized, and globally distributed. Lead times for processing files are shrinking. Demands on distribution are increasing. Files must be made available in a variety of formats and distributed using any number of deployment scenarios (B2B, P2P, P2G), and through global channels. Contribution is mobile. Reporters, sports fans, and other content creators are capturing and uploading content to the web and social networking sites, or sending files directly to consumers.

How do media companies keep up?

The supply chain needs to become fluid, predictable, efficient – and ubiquitous. File formatting standards help. However, the movement of files globally and internally needs to operate less like an error-prone relay race, and more like an interconnected, high-speed pipeline. Assets, regardless of size, should flow at a rate determined by the business (not at the de facto speed of bottlenecked protocols), across any available networks. The processing, inserting, and merging of asset files and formats should be easy or automated, using established workflows and IT infrastructure.

Broadcast IT needs help supporting this new business through elastic service architectures that scale non-disruptively based on supply and demand. Independent workflows could be easier to manage through interoperable service architectures, offering integration and consistency with justifiable returns.

File-based workflows provide the groundwork for moving to services through SOA, but not without planning and integration. Workflows, while easy to manage in their own respect, have become specialized, isolated silos; moving and managing files across workflows could be much easier.

This paper explains Aspera's design philosophy and position on a model for content delivery using commercial software integrated through open service-oriented architectures (SOA) and high-speed transport, Aspera FASP® and FASP AIR®. We will describe requirements and use cases where contribution, processing, and distribution can become more efficient, predictable, and integrated across workflows.

Overarching customer goals

Each company may have a discrete set of objectives that must come together in an ecosystem of content suppliers, processors, and distributors. Across the media supplier ecosystem, each company will want to consider the following attributes or goals. Later in the paper we will share technical details driving Aspera's partner solution model and functional design goals around each of these areas.

The high-level business goals are to increase efficiency, reduce operations costs, and maintain or exceed current service levels through increased predictability.

Maximize efficiency

New solutions should increase efficiency – by more fully utilizing deployed assets and infrastructure, eliminating unintended waste from weaker technology, and reducing management costs through simplicity or automation.

Where possible, build on what you own and know

Where possible, consider solutions to take advantage of and build on IP network, computer hardware, and software infrastructure already deployed. Data transfer technology should be maximally efficient over commodity IP networks. Virtualization software and cross-platform web services (SOAP, XML, REST) are other examples of building on what you know and have.

Eliminate artificial (and unintended) technology bottlenecks

Traditional approaches to reliable network data delivery using TCP-based protocols such as FTP, secure copy (scp), CIFS, and NFS are all artificially limited in efficiency and speed for transfers over the wide area network paths that are common place today.

These speed bottlenecks are most pronounced when network bandwidths are large, distances are large, and network conditions are challenging, which are precisely the conditions over which the global media supply chain is operating: we are moving file data globally and over varied IP networks, now including many forms of wireless mobile connections. The TCP protocol bottlenecks can be entirely eliminated with new approaches to reliable, large data movement, but the typical acceleration and data blasting solutions offered in industry and academia fail to solve the problem, and in some cases, introduce tremendous waste in bandwidth. Thus, new transport technology should be chosen very carefully.

Map out business processes carefully

Workflow form should follow function. Before orchestrating, authoring, integrating, or automating processes, it is important to understand the business flow and target key processes for automation. Starting small and incorporating change gradually is a strategy followed by many. Once processes have been mapped out, automation can benefit certain workflows and tasks. A key understanding is which processes to target first—and which will most benefit from automation.

Increase predictability for your business

Any way your company can reduce costs associated with meeting or reducing lead times and increasing predictability in file processing and distribution schedules should be considered.

There are two key aspects to predictability:

1. Meeting timeframes using global and regional networks of varying condition – inbound and outbound.

2. Creating consistent workflows, through automation and other means, provides predictability.

Using traditional (TCP-based) file transfer protocols, for example, is highly unpredictable, and a different technology approach is needed to maintain predictable data transfer rates across all conditions to meet critical media delivery timeframes. The source of the problem is the way that traditional TCP protocols regulate their transmission rate in response to network conditions. The transmission rate is directly dependent on the combination of round-trip time and network packet loss over the delivery path; both dimensions increase over wide area IP networks, and thus data transfer rates are highly dependent on the distance of the transfer. Additionally, delay and packet loss also increase on congested network paths, and are higher on average on emerging wireless (3G, 4G) networks. Furthermore, no amount of network engineering can sufficiently "clean the network" – i.e., remove the packet loss – to maintain full utilization of large bandwidth, over long distance links.

Let us consider transferring a large media file over a typical cross-US Internet path of 100 ms of RTT with a bandwidth capacity of 1 Gigabit per second (1 Gbps of throughput). The path itself must maintain a packet loss rate of 1 in 1,000,000,000,000 (1 trillion) to maintain a 1 Gbps transfer and keep the pipe full. Just one packet loss event will halve the throughput, require several minutes to recover the full transfer rate, and in the process waste over 8 GB of available throughput!

And, as distance or bandwidth increases, the loss rate must be even or less to maintain a 1 Gbps transfer. This is impossible on real-world networks, especially over the time durations required to move multi-Gigabyte and Terabyte sized data sets typical in the media and broadcast industry. Thus, for predictability in transfer times, a different protocol approach is needed.

Workflow integration using composition and process orchestration frameworks, with automation and tracking designed to scale with very large numbers of files moving through the pipeline, and for truly "highly available" usage, increases predictability. For example, a typical video on demand (VOD) advertising ingest workflow may be expected to process several hundred content files and several thousand schedule files arriving through network file transfers per hour, including virus checking, transcoding, archiving and reporting, and gracefully degrade on failure. Many conventional automation and managed file transfer tracking and reporting systems work well when file volumes and arrival rates are slow, but break down under load: reporting systems come to a crawl, automation processes fall behind or fail altogether, and single points of failure in the system, such as a failed or misconfigured storage system, can stop the entire workflow when they go bad.

Elastically scale the pipeline as needed, globally

The delivery pipeline should scale from a network (add or reduce bandwidth to adjust speed and increase number of concurrent transfers), server, and storage perspective. An essential capability of the underlying technology is the ability to start small and incrementally add resources to scale up performance and load, non-disruptively to workflows and users, and hopefully, with linear gains in throughput or better. In traditional and even "accelerated" network file transfer, scaling up support for highly concurrent transfer workflows and aggregate transfer speeds is limited – sometimes so much so that the underlying technology fails to support even a handful of concurrent transfers and maxes out commodity hardware at fractions of its capable performance. Today's typical computer hardware is capable of 1 Gigabit per second of file transfer throughput or greater with efficient transport software.

The underlying transport technology and software implementation should be able to support aggregate transfer speeds at Gigabits per second on commodity hardware and scale linearly in throughput with each additional transfer: 100 concurrent transfers ought to achieve the same throughput as 1 transfer at 100x the speed. And, concurrent transfers need to gracefully share limited network bandwidth and system resources with one another. Here, true congestion control and bandwidth sharing fairness is essential to avoid certain jobs from unintentionally denying service to other jobs by hogging limited bandwidth (or worse, drowning out other critical network applications such as email, web and other TCP-based traffic).

Finally, once network bottlenecks are overcome, the storage and file system become the next bottleneck. Aspera has found through performance benchmarking with many leading storage systems that this "last foot bottleneck", like the network bottleneck, can artificially limit transfer speeds to a few hundred megabits per second or less. This is especially problematic for naïve "UDP blaster" solutions that may write file data to disk out-of-order and thus further slow the I/O pipeline with unnecessary random access. As the number and speed of file transfers scales up, contention for limited I/O throughput requires a disk-based congestion control mechanism to automatically and gracefully regulate file transfer speeds to avoid overdriving the capacity, creating packet loss and stalling transfers, and to fairly share the available capacity between competing transfers and other workloads.

Interestingly, the storage I/O bottleneck becomes highly pronounced in the new cloud-based storage systems, such as Amazon S3, Azure Storage, and Open Stack Swift. These "object storage" based platforms offer tremendous promise to store very large numbers of media files with instant scale out to unlimited storage capacity. However, the available I/O interfaces offer HTTP-based PUT/GET access, which is not only limited by TCP performance over the wide area network, but also requires dividing large media files into individual chunks, and exercising many concurrent streams, to read and write from the storage at high-performance. This creates another design gap: to use these cloud storage systems calls for a high-speed transfer mechanism that can allow media files to be read and written directly to the storage over the wide area and masks the complexities of the local HTTP I/O interfaces.

Provide comprehensive security throughput

Security should be provided end-to-end and top-to-bottom. This includes secure user and endpoint authentication, authorization, encryption (at rest and in flight), integration with antivirus and other security technologies (such as directory services or identity management) deployed by an organization. Federal standards for encryption (AES-128) and FIPS-140 compliance should be met.

The typical problems in security are a failure to consider the entire transfer process as part of the secure pipeline, compromising security to obtain interoperability across platforms, and even fundamental misunderstandings in the uses of open standard cryptography. For example, some file transfer systems provide for authorized and encrypted transfer over the network, BUT do so with the transfer process running as a privileged or "root" user, essentially disregarding the fundamental access control of the file systems on either end, designed to enforce different user privileges. Vendors frequently promulgate the notion that "more bits" in cryptographic keys means stronger security, when in contrast, cryptographic research has continually shown that longer key algorithms can be even more vulnerable to certain attacks and at the cost of slower encryption times.

Consider service-oriented architectures (SOA) in the design

When appropriate, customers utilize new or established business processes to compose, integrate, and automate manual tasks, transforming manual processing functions to services, managed by IT. Workflow automation platforms should allow for programmatically adding and changing new third-party functionality without re-coding the core engine, which requires a generalization of third-party plug-in functionality, configuration and execution within the workflow platform, and a clean containment of complex workflow step logic within the engine.

Maximize interoperability without compromising performance

Industry-standards have matured. Windows talks to Linux and to Mac. Applications deployed on one platform can integrate with those running on another – through web services (SOAP, REST, XML), open APIs, SSH, and any number of commodity wire protocols (FTP, HTTP, SMB2, NFS, SCP) and application-specific APIs and management tools. Perhaps the single most common attribute of today's media file transfer pipelines is the need to smoothly interoperate transfers and automation across all of the operating systems and file systems in use today, while still maintaining performance and security. However, traditional managed file transfer and even "accelerated" transfer and delivery software often achieve platform interoperability in ways that dramatically compromise performance. An example is the pervasive use of Java and Java applets in transfer acceleration applications. These applications build their software in Java for a write-once/ run-anywhere approach. However, in practice, high-speed transfer performance is seriously crippled by the slow performance of the virtual code environment and the inability to obtain high precision control over functions like packet processing and I/O. For maximum performance transfer capability with the least system resources and high precision rate control, it is essential to write native code for every OS platform. This is phenomenally more difficult engineering with significantly more complexity, and requires test and deployment of a huge matrix of builds on the part of the vendor, but allows for true breakthrough performance and consistency in speed across desktop, browser, and server environments and across operating systems.

Technical design goals

Media companies managing one or more IT functional areas supporting contribution, processing, and distribution should consider the following section a primer on Aspera product design goals. Aspera has designed its solutions to address all three areas, focusing on the inter-relationships between each segment, contribution to processing, processing to distribution, and so forth.

Transport for efficiency, predictability, and scaling needs

At the bedrock of the technical goals for file delivery are the capabilities of the file transport. The efficiency, predictability, and scaling requirements can only be met with a purpose-built transport technology that overcomes the limitations of conventional TCP protocols and fills its design gap for bulk data transport over the wide area. Aspera has created a new (from-scratch, patented) transport technology called Aspera FASP that is designed to achieve maximum bandwidth efficiency, independent of network round-trip time and packet loss, for bulk data transfer of any size. As a result, the transfer speeds are predictable, given an available bandwidth capacity, regardless of network distance. The implementation of the protocol is designed to be lightweight on commodity computer hardware (using minimum memory and CPU), to allow for scaling to maximum throughputs (1 Gbps+ on commodity hardware) and maximum number of concurrent transfers (hundreds on commodity hardware) with a linear increase in aggregate throughput with each concurrent transfer. Additionally, using a novel file streamlining technique, FASP removes the artificial bottleneck added by round-trip delay in per file processing over the wide area, and achieves the same ideal efficiency for transfers of large numbers of small files. For example, one thousand 2 MB files can be transmitted from the US to New Zealand (RTT 200 milliseconds) with an effective transfer speed of 155 Mbps, efficiently utilizing an entire OC-3.

Finally, the technology has complete network and disk-based adaptive rate control, with congestion avoidance, designed to automatically adjust transfer speeds to use only the available bandwidth, considering the currently available network and disk bandwidth. The adaptation works at fine time scales and requires no centralized management or coordination; each transfer automatically adjusts its rate continuously in response to the presence of other data flows and thus allows the protocol to be used at scale on shared networks – on the Internet in the same spirit as other standard TCP protocols – without human intervention to tune or tweak bandwidth. The bandwidth usage is designed to allow for policy-based fairness controls to standard TCP traffic; meaning, transfers do not deny service to other TCP applications. The bandwidth control allows for dynamic and selective prioritization of individual transfer jobs if an application or operator chooses to speed up a given transfer at the expense of other traffic.

How FASP works in comparison to UDP data blasters

Aspera FASP fills the gap left by TCP in providing reliable transport for applications that do not require byte-stream delivery and completely separates reliability and rate control. It uses standard UDP in the transport layer and achieves decoupled congestion and reliability control in the application layer through a theoretically optimal approach that retransmits precisely the real packet loss on the channel. Due to the decoupling of the rate control and reliability, new packets need not slow down for the retransferring of lost packets as in TCP-based byte streaming applications. Data that is lost in transmission is retransmitted at a rate that matches the available bandwidth inside the end-to-end path, or a configured target rate, with zero duplicate retransmissions for zero receiving cost.

This is a fundamentally different approach than UDP data blaster approaches, such as UDT, Tsunami, Reliable Blast UDP, available in open source, repackaged and sold by many commercial vendors. These data blaster programs also transmit data over a UDP channel and have a mechanism to retransmit dropped data, but the mechanisms for doing so are simplistic and result in tremendous amounts of redundant retransmission data – resending file data that is already received – and dramatic overdrive of the channel capacity, resulting in unneeded packet losses and denial of service to other network applications and to their own flows. Their implementations do not scale with the increasing number of artificial packet losses caused and thus their effective file transfer rates collapse on wide area networks.

For example, one of the most advanced retransmission (NACK-based) UDP transport solutions, "UDT", is selected to demonstrate these problems. Through several hundred tests, we measured the file transfer throughput of UDT transferring a single large (5 GB) file between two commodity Linux servers (Ubuntu Server 8.10 with Linux Kernel 2.6.7, Intel Core2, Quad CPU 6600 2.40 GHz, 4GB RAM), connected via a FreeBSD server running the Dummynet network emulation software to emulate the round-trip time, packet loss rate, and bottleneck bandwidth of a wide area network.

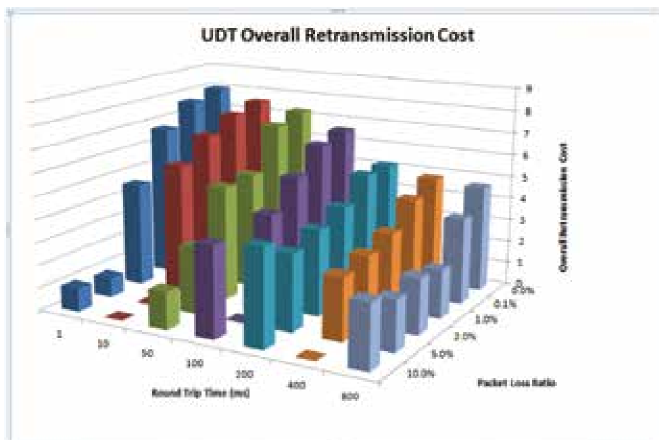

Figure 1: Shows the overall cost of transmitting one packet by a single UDT transfer on a T3 (45 Mbps) link under different RTTs and packet loss ratios. For most typical wide area networks, one packet transfer needs eight to ten retransmissions!

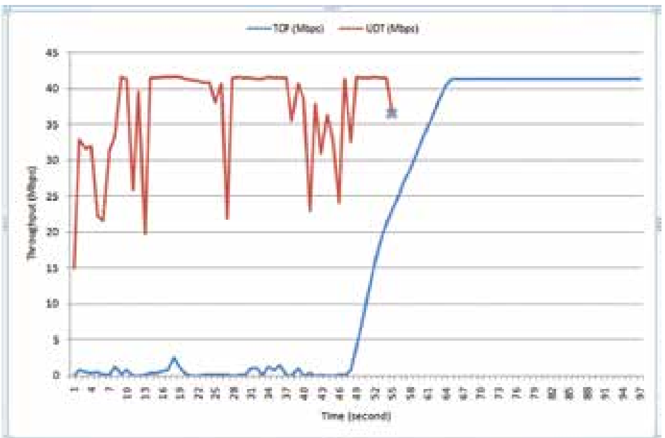

Figure 2: Shows the denial of service caused to a standard TCP flow due to the lack of proper congestion control in UDT.

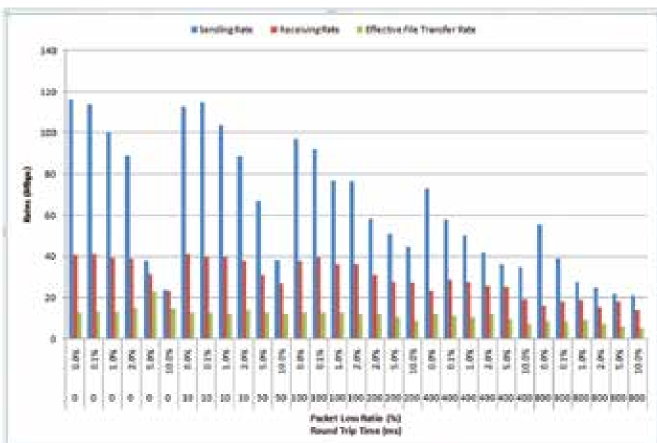

Figure 3: Difference in transmission rate, receiving rate, and effective file transfer rates for UDT on WANs.

Figure 3 above shows the dramatic difference in transmission rate, receiving rate, and effective file transfer rate for UDT on typical wide area networks. Much more data is transmitted than is available on the network (the "sending cost"), and what is received is largely redundant data already received, due to naïve retransmission, (the "receiving cost"), leading to slower actual effective file transfer rates, even though the network looks full. The bar graph shows the sending rates, receiving rates, and effective rates of a single UDT transfer under different RTTs and packet loss ratios on a T3 link. Note that the large difference between sending and receiving rate implies large packet loss on the intervening network path, and the large difference in the receiving and effective rate implies a large number of duplicate retransmissions.

In Aspera FASP, the receiving cost is minimized to zero through a mathematical control system and software implementation that avoids any duplicate retransmission. The sending cost is minimized to zero by automatically discovering the available bandwidth inside the path through a delay-based rate control mechanism, which obtains the precise estimation of network congestion, not artificially slowing down over networks with packet loss due to the media.

Figure 4 below shows the throughput achieved under various packet loss and network latency conditions on a 1 Gbps link for file transfer technologies that use FASP transfer technology. Data was obtained by measuring the transfer throughput of a 5 GB file for FASP running on Linux 2.6 on commodity hardware (Intel Core2, Q6600 2.40GHz, 4GB RAM< 3x10,000 RPM SATA drives), interconnected by a 1 Gbps network with a commercial network emulator used to inject RTT and packet loss. The table shows the detailed sending and receiving costs and the effective file transfer rates.

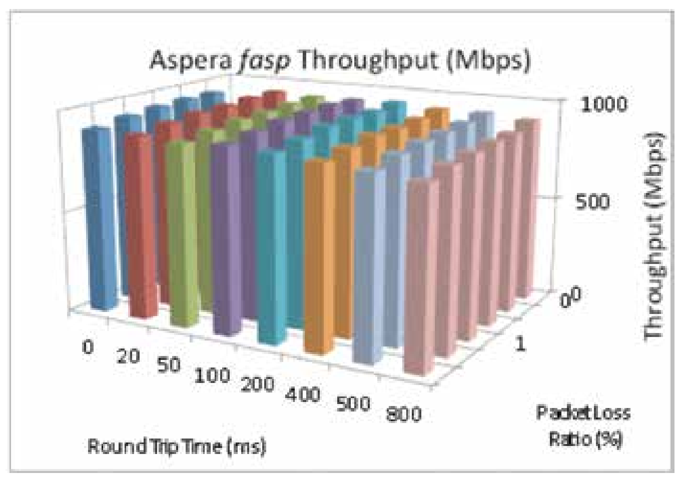

Figure 4: Throughput achieved under various packet loss and network latency conditions on a 1 Gbps link

The quick response mechanism allows high-speed file transfers to automatically slow down to allow for stable high throughput when there are many concurrent transfers, but automatically ramp up to fully, efficiently utilize unused bandwidth for the most efficient delivery times. Stable transmission speed brings QoS experience to end-users without any additional investment on QoS hardware or software. Delivery time of data becomes predictable and data movement is transparent to other applications sharing the same network.

In addition to efficiently utilizing available bandwidth, the delay-based nature of FASP adaptive rate control allows applications to build intentional prioritization in the transport service. The built-in response to network queuing proves a virtual "handle" to allow individual transfers to be prioritized/de-prioritized to meet application goals, such as offering differentiated bandwidth priorities to concurrent FASP transfers.

Continuous availability for business-critical workloads

Customers require workflows to be available 24x7. Workflows used for ingest, file processing, and distribution must remain continuously available and resilient to failure. If the workflow stops, business stops. One of the design goals is to support non-disruptive, multi-node upgrades, and comprehensive high-availability – managed through a central entity and usable through standard browser interfaces. The full file transfer and workflow solutions from Aspera, detailed in the Use Cases section, (see p. 12), are designed such that the transfer mechanism, the reporting, and the automation continue to work across transfer failures, and can be deployed as highly available services that can be independently monitored and failed over through modern clustering solutions on Linux, Windows, Isilon, and other clustered systems, and deployed in conjunction with standard load balancing systems. To sustain management of large numbers of files at high speeds, and large file sizes, the API implementations for transfer automation and reporting require that the APIs themselves be designed to scale and to deal with failure. For example, third-party programs using Aspera APIs are able to control the rate at which they receive transfer progress statistics from many concurrent transfers running on nodes over widely distributed networks and to pick up "missed" history if and when the third-party application goes down, and can retry and resume transfers that fail in any stage of the pipeline.

Simplifying contributions

When multiple suppliers need to contribute content, they need an easy, secure, and cross-platform set of tools that simply work. Once content is received, it must be securely transitioned for internal processing.

These can be basic file upload tools, or more advanced point-to-point, point-to-multipoint, or person-to-person collaboration solutions. The key requirements are that they are:

- Easy to deploy and easy to manage: Tools should be easy for end-users with little training to install and use within a supply chain ecosystem, and should be as easy to manage with a large number of contributors as when first deployed.
- Fully secure: Security should be maintained on a number of levels – authentication, authorization, the files at rest (locally), the transport, and files at rest remotely, once uploaded.
- Offer highly predictable performance: Both regional and global suppliers should obtain the same predictability in file transfer speed, irrespective of location, network quality or type, or system type. As wide-or metro-area bandwidth to a facility increases, the contribution system should scale with it – fluidly, up or down – both by scaling on the wire (as bandwidth increases or allocations shrink) and in storage (as CPU and disk IO increase).

Band-width (Mbps)	RTT (ms)	Pir (%)	How much data to be sent? (MB)	How much needs to be sent (actual data+ inevitable loss by media, MB)	How much data actually sent? MB)	Sending Price (Sender's overhead, %)	How much data actually received? (MB)	Receiving price (receiver's overhead, %)	How long does it take?(s)	Effective file transfer speed (Mbps)	Observed network utilization (by receiver)	Network efficiency (effective utilization, %)
45	0	0	953.7	953.7	953.7	0.0%	953.7	0.0%	185.4	43.1	98.5	95.9%
45	100	1	953.7	963.2	963.3	1.0%	953.7	0.0%	187.8	42.6	97.1	94.6%
45	400	5	953.7	1001.4	1002.1	5.0%	954.3	0.1%	197.0	40.6	92.1	90.3%
45	800	5	953.7	1001.4	1003.5	5.1%	955.2	0.2%	197.0	40.6	91.6	90.3%
100	100	1	953.7	963.2	963.3	1.0%	953.8	0.0%	85.0	94.1	96.3	94.1%
100	200	5	953.7	1001.4	1002.4	5.0%	954.5	0.1%	88.9	90.0	91.9	90.0%
300	100	1	953.7	963.2	964.0	1.0%	954.4	0.1%	29.3	273.4	92.6	91.1%
300	200	1	953.7	963.2	964.7	1.0%	955.1	0.1%	29.2	274.3	91.9	91.4%
500	200	1	9536.7	9632.1	9635.0	1.0%	9539.0	0.0%	181.6	440.6	90.6	88.1%
500	200	5	9536.7	10013.6	10018.5	5.0%	9541.2	0.0%	186.9	428.0	88.0	85.6%

Table 1: Aspera FASP file transfer over Typical WANs - near 0 Bandwidth cost and fast transfer rate

- Cross-platform: Customers use all variations of operating systems (Linux, Mac, Windows etc.), browsers, and mobile platforms, such as Apple iOS and Google Android devices, and all range of platforms must be supported for large-scale global scenarios, without compromising the performance and usability.

Securely transitioning content for internal processing

Through workflow integration and automation, contribution systems can be configured to safely automate file movement to subsequent steps in the workflow – such as moving files from a frontend antivirus system to the back-end and next phase in the workflow, such as quality control. Remote contribution overlaps with internal processing in the demilitarized zone (DMZ). For this process to remain secure, contribution/ingest systems must be locked-down, while also serving as a multi-tenant target for many independent contributors. Once content is received into a private secure area for each content provider, it must be securely transitioned (copied or moved) from the DMZ, across a firewall, to the mid-tier or back-end storage and application servers, based on any number of content security policies.

Some companies rely on enterprise antivirus protection through off- or on-box virus scanning; as content comes in, it must be scanned before being moved or copied into the internal workflow. Thus, the first phase of automation can be provided by automating the movement of content from a DMZ safe zone to the first step in a workflow, such as quality control. The major points of integration required to automate this process are frontend gateway systems, enterprise storage, and antivirus.

Major media customers use any number of storage and antivirus products. The contribution and processing system should integrate with both the storage and antivirus systems.

- Enterprise storage integration: Software must have some way of communicating with the underlying storage system to enforce secure private areas of the file system for the uploads from each content provider, and a mechanism to automate the movement of files on arrival. Aspera's strategy enforces secure document roots in conjunction with the authenticated user account for each transfer and transfers directly to the file and storage system, supporting all industry-standard file sharing standards for the broad majority of NAS and SAN vendors. Some systems, such as Isilon OneFS, integrate the Aspera server software directly on the storage appliance.
- Antivirus integration: Aspera's products integrate with ICAP to enable off-box antivirus scanning performed by dedicated antivirus systems before files are moved to back-end data center processing steps in a workflow. Rules can be configured using Aspera's orchestration framework honoring a company's antivirus or security policy (e.g., quarantine, log, or delete files based on events).

Build on what you own and know

Commercial software from Aspera and other media partners can be configured and extended to provide highly available service-oriented architectures (SOA) using established business process and IT infrastructure. Deployed file-based workflows and policies provide the groundwork for identifying targeted business processes, composition areas, and transforming manual processes to automated services, where appropriate. These include but are not limited to: FTP, antivirus, encoding, quality control, transcoding, watermarking, and DAM/MAM automation.

An open platform architecture should provide extensibility, composition, and optionally integrate client and server components available through industry standards. While Aspera FASP transport provides breakthrough advantages in speed, efficiency and bandwidth protocol over legacy transfer protocols, FASP is a new technology and is not deployed universally. The automation tools provided by Aspera allow for identifying and ingesting content uploaded with any transfer mechanism, allowing companies to build on what they own and to fully automate files ingested by FTP and other means into the same targeted processes as part of its content delivery initiatives for contribution, processing, or distribution.

Aspera provides an authoring and composition framework for designing, integrating, and adapting workflows based on business process. While this paper will not detail the specifics, the following section describes Aspera's design philosophy on workflow integration. One of the design goals was extensibility: enable integration with established media vendors and technology investments such that file movement can be automated across workflows at the right level.

Integration layers

Integrating with business-critical media workflows is usually not a one-size-fits-all proposition. Some level of pre-configured integration can be provided through plug-ins to popular media-specific workflows. In support of simple workflows, plug-ins provide a good starting point; file movement and management can be automated and tracked for some applications. However, for complex workflows, the form of integration needs to follow the function of the deployed applications and established (or new) business processes.

With the advent of industry standards, web services, and service-oriented architecture (SOA) developers have a broader tool chest of configuration options and integration paths. The orchestration of those paths depends on your business – and business process. Integration can be achieved at either a higher- or lower-level, depending on the customer goals. Lower levels include the data, information, and process layers. While all are critical, the level of integration may vary widely from customer to customer.

From a media operations perspective, these integration layers may include:

- Wire protocol interoperability: The most basic level of integration is on the wire protocol, and demands full interoperability with standard IP networks. Aspera FASP has a well-defined wire protocol that is fully compatible with IPv4 and IPv6 networks, and industry-standard NAT, uses path MTU discovery to appropriately size datagrams to the myriad of network paths over which it operates and implements a full congestion control protocol that is compatible with standard TCP and bandwidth friendly for concurrent transfers on both public and private network segments. The protocol is versioned and runs on all standard operating systems for scalability across customer deployments and versions.
- Directory-level: The ability to create rules for an individual directory provides basic automation. When a file is written to a directory on a file system, some pre- or post-processing action is performed on the directory-level. For instance, a file could be automatically moved to a target location based on a rule. The rule could be matching a file type or name, or other criteria.
- API-level: Applications and operating systems have a range of interfaces which can be utilized to interact and manage files, which may range from simple move, rename, and list commands to more sophisticated file transformations such as encoding and transcoding.
- Web services-level: Most third-party systems today support web services based APIs for programmatically utilizing their primary functions in a loosely coupled, distributed workflow. These APIs build on SOAP principles, and may use any combination of REST, XML-RPC, ICAP, ATOM and other protocols. Workflow automation should extend easily to take advantage of these as an application-agnostic means of integrating over networks, within (and in some cases) between locations.
- Database-level: SQL Server, Oracle, MySQL and other databases support a rich set of interfaces, through XML, XPATH, and proprietary APIs. Many media applications today utilize these APIs in the storing, searching, indexing, and processing of files and structured data.
- In-box tools: Many applications and platforms come with a rich set of command-line scripting and automation tools which can be utilized.
- Management-level: Customers often use popular management frameworks such as Microsoft Systems Center Operations Manager (MS SCOM), HP OpenView, and Tivoli, among others. Some products are supported through plug-ins out of the box. Aspera offers numerous integration strategies to other products, using REST and CLI interfaces to any number of collection and reporting techniques. All reporting functions are extensible, and can be exported to industry-standard formats such as XML and CSV file formats.

The business process and deployed applications determine the appropriate level of integration. Movement of files across internal workflows can be partially or fully automated, and fully tracked for auditing and reporting.

Integration with third-party vendors

Integration is typically not a one-size-fits-all proposition. The good news is that Aspera and partner companies are constantly integrating new capabilities and new integration plug-ins – to do as much of the work as possible up front, and on top of a workflow and automation platform that contains and generalizes the workflow execution logic. Plug-ins can be considered building blocks to jumpstart integration with target managed applications and third-party frameworks. IBM® Aspera® Orchestrator has an extensible plug-in architecture and plug-ins developed in partnership with third parties for quality control, transcoding, ad insertion, virus checking, notifications, user input, and other actions.

File processing decision tree and flow

One scenario for internal processing is quality control. Quality control (QC) is an area where dependencies on human decisions and actions converge with rules processing and automation. For example, there is an Aspera partner that provides Automated Content Verification software to help ensure cross-format content readiness in media workflows. In this scenario,a file has passed an antivirus check (step A) and is sent to the QC workflow (step B). A notification can then be sent to an operator (step C) to make sure the file meets quality standards. Rules can then be configured to move the file from QC to transcoding once the operator has physically ensured the file meets a set of criteria in step D (where E may represent transcoding or another step in the workflow).

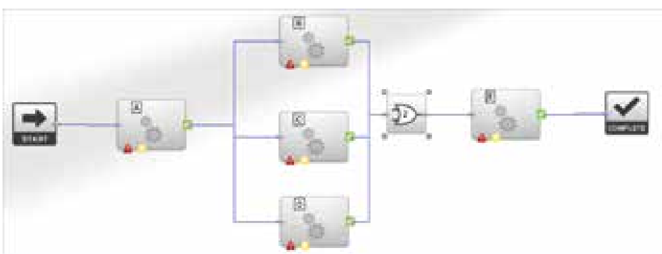

Figure 5: Designing a file processing decision tree and flow in Aspera Orchestrator

Modular extensibility

A key capability in workflow integration is the ability for developers to adapt the system as needed, or provide deeper or custom levels of integration where appropriate. It should be noted that a common platform and SDK is supported on Aspera, where investments can be adapted over time, and integrated with third-party applications incrementally, as needed over time.

In the case of Aspera Orchestrator, for example, new plug-ins or custom-developed scripts can be loaded and deployed across any system in the management domain. The process of adapting and creating new interfaces and plug-ins should be straightforward. For example, there are two basic scenarios that can be utilized through Aspera's composition framework:

- Vendor-specific, pre-configured plug-ins are loaded: In this case the plug-in calls an executable, using web services, APIs, or interfaces provided by the vendor. Execution can be local or remote.
- Ad hoc scripting: a script or scripting container can be loaded to enable a developer to script on the fly specific operations or integrate into an application. Execution can be local or remote.

For example, rules for moving or copying files can be configured, where a source and target destination is defined. This can be used in the context of any workflow, such as post-processing files after a virus scan to move them into a new directory, marked as safe, once a scan is complete.

Automation

The level of automation required should be determined by business process and job function, and may be combined with manual steps such as human decisions for review and approval. Workflows need to be designed such that the right process moves the file to the right place. This may or may not involve automation. As such the composition framework should provide:

- Open API for third party application integration.
- Parallel execution of all actions – local and remote.
- Both unattended and interactive workflows (as in QC).
- Ad hoc execution or on-going recurring (scheduled) execution of processes.
- Ability to define sub-workflows that can be used as reusable building blocks.

Processing multiple files in a virtual package

In many media workflows, metadata needs to closely follow essence or duplicate files. The group of files needs to either move across the workflow as a group, or be processed in the right order. It is important to provide an architecture that can move, manage, and process files in the right order or sequence based on policies defined by the workflow or business rules. Automating file movement and transformation must follow established business rules and processes. For example, in one broadcaster's workflow, metadata and content files arrive from providers not necessarily in any particular workflow. The workflow automation logic must wait to forward incoming content files until the corresponding metadata files arrive, group the metadata files with the content into the same directories on forwarding, and notify operators in case the entire package is not received.

The image below depicts how multiple inter-dependent files are processed across a workflow.

Fine-grained tracking and reporting

Management and reporting requirements will depend largely on the workflows being managed. A key need for most workflows is fine-grained tracking and reporting of business-critical actions.

This can be performed within each workflow, aggregated and collected using management information, or piped directly to a third-party management framework. Aspera provides plug-ins for frameworks such as Microsoft Systems Center Operations Manager and others. In the case of a VOD advertising pipeline, all contributors are notified via email notification and a Microsoft SCOM notification is generated when the scheduling and content files are successfully received in the workflow.

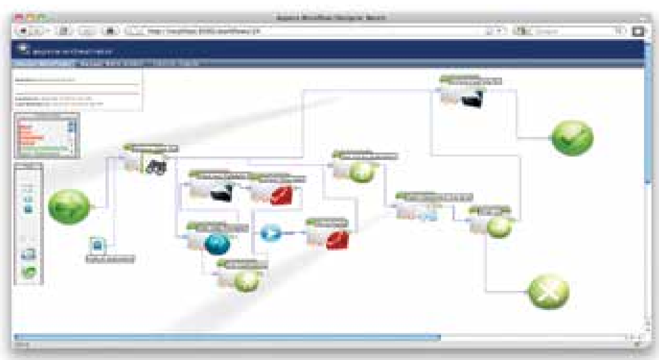

Figure 6: View of the Workflow Designer in Aspera Orchestrator

Distribution requirements

A key requirement for distribution is flexibility – both from a media format and deployment model perspective. The distribution solution should be format- and media-agnostic. The target media could be physical (DVD) or digital (a file type).

From a deployment perspective, some scenarios may require point-to-point (within a company or B2B), multicast, person-to-person, publish-subscribe, in any combination, as described below:

- Point-to-point: The most basic distribution model enables sending files from one location to another, either one-way or bi-directionally (back and forth).
- Multipoint: In scenarios where VOD or a large number of files needs to be efficiently sent from a single point to many points using satellite or terrestrial multicast IP networks, the solution should support it – across distance and varying network conditions, and with both interactive desktop, browser, and automated capabilities.
- Person-to-person: More and more companies need an automated way of getting large content sets from one person located in one place to another person or group of people located remotely. A key challenge in this scenario is providing easy-to-use solutions which meet a diversity of customer needs – and work in most any environment, even with large distance and large numbers of files delivered.

In combination with person-to-person scenarios, customers require easy ways to push or pull content on demand, either through user controls or automatically via policies, scripts, or schedules. Aspera products are designed to support this wide variety of workflows in deployments of any size.

Customer use cases

Use case 1: easy contribution and automation

Many customers today need a simple, easy to install tool kit to send and receive content from partners. This can be as simple as a single client (the origin) sending files to a point-to-point client, server, or highly available cluster (the destination). Basic automation and forwarding supports moving files from server to server based on simple directory- or folder-specific rules called Hot Folders.

This can also be scripted. The world's leading provider of satellite uses a scripted configuration to simplify delivery of HD content from providers to broadcast satellite operations. It is easier to manage than FTP and scales performance and capacity for contribution and file processing.

Use case 2: advanced contribution and integration

Similar to the above scenario, but in some cases customers need file movement and processing deeply integrated with the media workflow. Content comes in from multiple providers running different operating systems and platforms, and is directly ingested and processed across a diverse workflow.

One example is a leading subscription television provider in Australia, that services content from 200 channels to over 1.6 million homes. The provider needed an easy ingest contribution platform that integrated with third-party processing applications, for encoding, transcoding, watermarking and content verification. Folding in content preparation steps into the file transfer process will boost overall performance of the broadcast supply chain.

Advanced reporting capabilities are often required to quickly track and audit exchanges with other media and production companies. In some cases, companies prefer an out-of-the-box management solution. In other cases, management information should be collected and piped into a third-party management framework.

Use case 3: high-volume processing and transformation

Top-tier service providers and media companies receiving extremely large and growing amounts of data need to rapidly and predictably scale resources for contribution, processing, and distribution.

The entire pipeline must scale network and storage performance to accommodate large data sets. Processing must be tightly integrated across workflows – to provide consistency, predictability, and continuous availability.

For these companies, the volume of content ingested, scanned, and transformed is both extraordinary – and growing. One Aspera customer receives and processes over 600 videos an hour, in support of 6000 file processing steps. The steps include automating the processing and transformation of multiple files per video for such processes as ad insertion. The total workload amounts to over 500 million files processed each week.

In these cases, the workflow is mission-critical – and must accommodate large-scale workloads. Moreover, the file processing workflow needs to be adaptive: as new steps or processes are added, or changed, the system needs to accommodate the changes non-disruptively. The diagram below shows a representative workflow for ingest of content and scheduling files, processing through virus checking, forwarding, transcoding and archive and finally notification of the status to the standard health monitoring system and back to the providers, as well as centralized tracking through a single browser-based Console interface.

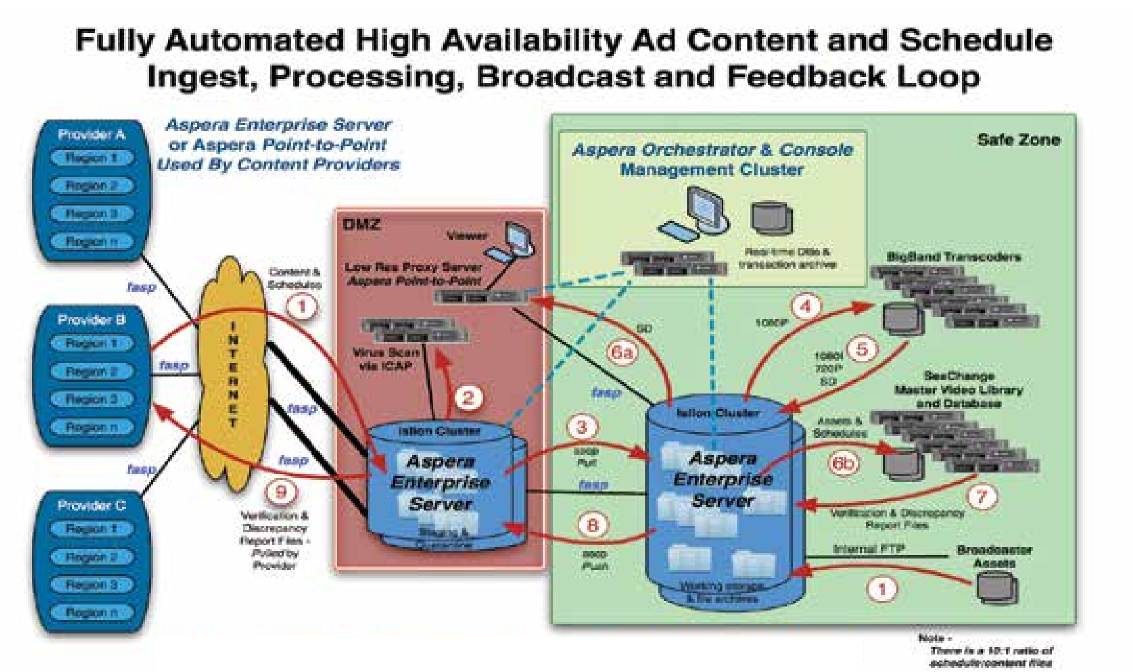

Figure 7: Simplified workflow representations under Aspera Orchestrator control

Use case 4: collaboration

Many customers use a mix of tools and technologies for contribution, processing, and distribution – and need a way to collaborate on assets across all phases of the delivery pipeline. Customers often need a system for person-to-person and dropbox style collaboration, where an email including a URL link can be sent. A key need is that these tools are exceptionally easy to use and manage, and are versatile to work within a variety of workflows – in and between organizations.

For example, an editor may need to send a director a clip for review. Aspera provides simplified collaboration tools (such as IBM® Aspera® *faspex*™ server and IBM® Aspera® Cargo automatic downloader) to package the files, rapidly upload them to a website, and send a link to the reviewer. The reviewer can be setup to automatically pull the files, or download them manually.

Collaboration tools are ideal for person-to-person distribution – for example, moving content from upstream providers to affiliate stations – where clients can be configured to automatically download or "pull" content.

Use case 5: flexible distribution

In cases where content is created on site (or received through an existing process), some customers simply need to distribute the content for playout or to another organization. The target format could be any file type or media. The primary scenarios are point-to-point, point-to-multipoint, bi- or multi-directional synchronization, and person-to-person. Aspera provides distribution tools to address each of the above scenarios.

Use case 6: ultra high-speed ingest

For scenarios where high-performance is required, Aspera has integrated its contribution and ingest platforms with leading storage partners to obtain linear storage performance scalability across metropolitan and longhaul networks, over any distance, with speeds of 10 Gbps and beyond. For companies involved in production, content delivery networks (CDNs), and high-speed B2B scenarios, these solutions can complement or replace established ingest systems such as FTP.

Over the years, Aspera has established strategic partners with storage vendors to enable highly scalable storage-to- storage performance using any network – from 1 Gpbs to 10 Gpbs – and providing customers with a way to scale transfer speeds to support rapid contribution, processing, and distribution.

Summary – achieving predictability throughout the pipeline

For many companies, the costs associated with lead and processing times are quite high to provide some level of predictability. It is safer to send a tape via overnight than risk a schedule slip using IT technologies that may fail because content is especially large, or the network distance is great, or a large number of concurrent jobs are kicked off at the same time.

The reality for business is that predictability should be achievable irrespective of the move to IT systems and irrespective of distance, location, load, or other timings. Aspera has patented a type of transport to make use of networks of varying media, speeds, and conditions. The transport is location-agnostic, providing full use of available bandwidth independent of network type, quality, or speed and able to scale with data set size and transfer load. Additionally, with properly designed software systems that scale up with very large numbers of files and frequency of processing, and that have loosely coupled components that each can be made highly available, and that can be extended for new functionality, IT systems can perform with increased predictability over former physical media / tape processing pipelines. The end-to-end workflow automation approach being proposed builds on these principles and offers a way forward to actually realize the promised benefits of file-based IT systems for dramatic productivity increases and dramatic cost savings in the global media supply chain.

About Aspera, an IBM Company

Aspera, an IBM company, is the creator of next-generation transport technologies that move the world's data at maximum speed regardless of file size, transfer distance and network conditions. Based on its patented, Emmy® award-winning FASP® protocol, Aspera software fully utilizes existing infrastructures to deliver the fastest, most predictable file-transfer experience. Aspera's core technology delivers unprecedented control over bandwidth, complete security and uncompromising reliability. Organizations across a variety of industries on six continents rely on Aspera software for the business-critical transport of their digital assets.

For more information

For more information on IBM Aspera solutions, please visit ibm.com/software/aspera and follow us on Twitter @asperasoft.

IBM Corporation
Route 100
Somers, NY 10589

Produced in the United States of America
January 2015

ZZW03331-USEN-01