



Accelerating Olympic Winter Games Footage from Sochi, Russia to Stamford, CT

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Abstract - This paper examines how NBC Sports Group ensured the efficient file delivery of the 2014 Olympic Winter Games event footage between Sochi, Russia and Stamford, Connecticut to facilitate remote production using the FileCatalyst Direct solution. The file transfer objectives set for the event included the high speed delivery of event footage over a global connection, the high speed delivery of event footage over a regional connection, the transfer of large, dynamic file sets consisting of up to 100 videos, and the successful transfer of non-standard MXF files. While working to meet these file transfer objectives, NBC Sports Group faced several challenges including latency, packet loss, reliability, and obtaining a solution which could execute the concurrent transfers of growing files. After evaluating several file transfer alternatives, FileCatalyst Direct was selected and successfully deployed to deliver all event footage for the 2014 Winter Olympic Games

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Introduction

Producing a live sporting event is, at the best of times, a challenging proposition for broadcasters. With multiple cameras producing massive high resolution video files, moving the video files for in-studio editing can be a daunting task. Even with a high bandwidth link and an accelerated and managed file transfer solution in place, there are sometimes other distinct obstacles which must be addressed. In addition, in today's digital age it is expected that content (i.e. highlights, mash-ups) will be made available in near real time via all mediums including live broadcast, the web, and mobile devices.

In 2013, NBC Sports Group, consisting of NBC Sports, NBC Sports Network, Golf Channel, NBC Olympics, 11 NBC Sports Regional Networks, two regional news networks, NBC Sports Radio and NBCSports.com, required the fast, efficient and reliable transmission of live sporting footage for the upcoming 2014 Winter Olympic Games. From February 7 to February 23, 2014, NBC Sports Group would feature live coverage of the 98 events in 15 Olympic sports, and required a file transfer solution which would

enable remote editing and post-production of the events from its headquarters in Stamford, Connecticut.

During its coverage of the London Summer Olympics in 2012, NBC Sports Group realized it was becoming increasingly comfortable with performing live sporting event production from a remote location. There was great opportunity to reduce on-site editing and logging as there was no longer a need to ship historic tape archives around the globe. Instead, any files requiring post-production could be sent from Sochi, Russia to Stamford, Connecticut for editing, and then sent back to Sochi for broadcast or sent out directly for web and mobile delivery. Furthermore, any archived video clips from past Olympic Games coverage could be requested and transferred from Stamford, Connecticut back to the Sochi Broadcast Center for broadcast faster than they could have been ingested from traditional videotape.

A year prior to the event, NBC Sports Group's legacy file transfer software was decommissioned, as it was no longer supported. It was apparent that it required a new file transfer solution for event coverage of the 2014 Winter Olympic Games. NBC Sports Group set objectives and outlined requirements to implement effective and efficient file transfer practices that would ensure the fastest and most reliable transfer of event footage. The goal was to ensure the ease of remote editing and production for Olympics coverage that would be broadcast throughout the United States to more than 80 million homes via cable and satellite [1]. Equally essential was the ability to deliver Olympics footage quickly so that it may be made available as close to real time as possible to all other mediums including the web and mobile devices for convenient viewing access.

Objectives

Prior to researching file transfer solutions for the 2014 Winter Olympic Games, NBC Sports Group outlined a set of specific objectives required to efficiently and effectively deliver event footage to enable reliable file transfer for remote production and other event coverage needs.

The required targets included the high speed transfer of event coverage over a global connection, the high speed transfer of event coverage over a regional connection, the transfer of large, dynamic file sets and the successful transfer of nonstandard MXF files.

High Speed Transfer of Event Coverage over a Global Connection

NBC Sports Group required a solution to effectively transfer both high-resolution and proxy videos of live event footage at the 2014 Winter Olympic Games from Sochi, Russia back to its headquarters in Stamford, Connecticut for in-studio editing and post production. These video files were reviewed and logged and tagged with metadata, allowing for fast retrieval of specific clips (i.e. for certain athletes) when required. These transfers were intended to be sent across dual 1 Gbps links (teamed together as a 2 Gbps link) spanning from Sochi to Stamford, utilizing the full connection speed.

In addition to sending content from Sochi to Stamford, it was equally important to transfer video content from Stamford to Sochi. For example, if a live broadcast mentioned the coverage of an event earlier in the day or even a past Olympic games, NBC Sports would require a clip from that previous event to broadcast. NBC Sports' archiving system was able to perform a search on an athlete based on logged metadata, retrieve all past footage of that athlete and move it from tape archive onto an Omneon MediaGrid, both located in Stamford.

High Speed Transfer of Event Coverage over a Global Connection

Although the 2014 Winter Olympic Games in Sochi was cited as the most compact Winter Games in the history of the Olympic Movement, NBC Sports Group required a method for fast and efficient regional transfers from various event venues back to the broadcast location in Sochi. [2] The Sochi sporting event venues were grouped into two main areas: the Coastal Cluster and the Mountain Cluster.

The Coastal Cluster included the Bolshoy Ice Dome and Shayba Arena, location of the Men's and Women's Ice Hockey, the Iceberg Skating Palace which hosted the Figure Skating and Speed Skating events, and the Ice Cube Curling Center, home of the Men's and Women's Curling events. A dedicated 1 Gbps link was deployed to the Coastal Cluster.

The Mountain Cluster was the location of Rosa Khutor Alpine Resort, host of the Alpine Center and the Extreme Park where all downhill skiing and snowboarding events took place. Other venues at this location include the Laura Cross-Country Ski and Biathlon Center as well as the Sanki Olympic Sliding Center, home of the Luge and Bobsled events. A 1 Gbps shared link was used to transfer files from the Mountain Cluster.

Transfer of Large, Dynamic File Sets

With multiple events taking place simultaneously, NBC Sports' specific solution requirements included software that could handle extreme concurrency of file transfers (i.e. the transfer of several files, up to 100 files or more, concurrently). NBC Sports' file sets included multiple static and/or dynamically growing files in various directories from different sports venues, and represented transcoded feeds from cameras recording live video, as well as the associated metadata files for context and archiving purposes. The solution was required to handle potentially hundreds of file transfers at any given time.

NBC Sports needed to ensure all event coverage was transferred to its destination as close to real time as possible. Hence a further requirement was that while transfers were already in progress, the solution had to monitor for new files and begin transferring them immediately, without waiting for the previous file set to complete.

Successful Transfer of Non-Standard MXF Files

The majority of files which NBC Sports required for transfer were MXF (Material Exchange Format) files. These files are simply a container or wrapper for an underlying video and are described by their associated metadata file. [3] Since the internals of MXF files are not standardized, the files are created in different ways by varying 3rd party tools. For example, the file may start as 0 bytes and grow until it is completely encoded. It may also be created with its final size and the content of the file is continually updated. In addition, its associated metadata files may be updated continually throughout the process, or not generated at all until after the file transfer is complete. These factors cause traditional file transfer solutions to break down, resulting in corrupted or incomplete files. NBC Sports required a solution which could efficiently handle the transfer of MXF files, without the occurrence of any corrupted files or incomplete transfers.

Challenges

While working to meet its file transfer objectives for the 2014 Winter Olympic Games, NBC Sports Group faced a number of challenges. Some challenges were general obstacles related to file transfers over wide area networks (WANs) using various traditional file transfer methods, while others were specific to NBC Sports Group's unique file transfer scenario for the Winter Games. These challenges included latency, packet loss, reliability, and the transfer of large, dynamic file sets.

Latency

When transferring files between two locations with large geographic dispersion over a TCP/IP protocol (i.e. when using FTP) latency is a factor which can greatly slow down file transfer rates. Since TCP/IP requires the receiver to acknowledge each data packet of a file being sent in sequential order, each communication is measured as round trip time (RTT or latency) and is the time it takes for a packet to be sent and acknowledged. [4]

TCP then responds to latency by adjusting the amount of unacknowledged data that can be on the link before waiting for a reply. Latency is an impediment to sending files at full line speed, meaning that NBC Sports Group's 2 Gbps global link would not be used to its full extent if using FTP as its file transfer method. Due to the large file sizes of the event footage being transferred from Sochi to Stamford and back, the 2 Gbps link needed to be used to its full extent in order to efficiently transfer NBC Sports' digital content for broadcast.

Packet Loss

Another file transfer limitation associated with TCP/IP is packet loss. Network congestion when transferring files typically causes buffer overflows of intermediate routers, causing packet loss. Since packets are sent sequentially, this can cause a hold-up in the cycle. Unacknowledged packets also cause the TCP window to shrink or even close completely for periods of time. On the long haul link from Sochi to Stamford, the number of hops and volume of data being transferred will lead to some congestion. Even minimal packet loss can affect the top speed of a TCP transfer, especially at speeds of 1 Gbps or higher.

Reliability

Traditional file transfer methods such as FTP are unable to offer reliability for file transfers. Unlike accelerated file transfer solutions, FTP cannot perform MD5 checks to ensure file integrity. [4] NBC Sports noted that reliability

was key in ensuring the effective coverage of the Winter Games and ruled out any file transfer solutions which could not guarantee file delivery. Furthermore, as previously mentioned, the transfer of non-standard MXF files caused traditional file transfer solutions like FTP to break down and resulted in corrupted and/or incomplete files.

Transfer of Large, Dynamic File Sets

When researching various file transfer solutions, NBC Sports noted that the ability to transfer large, dynamic file sets was not a standard feature among accelerated file transfer software vendors. As one of NBC Sports' main file transfer objectives was a solution that could seamlessly handle up to 100 concurrent transfers of video files that may still be growing, the requirement was a determining factor in selecting a file transfer solution.

Solution

After evaluating several accelerated file transfer options for the 2014 Winter Olympic Games, and completing proof of concept work with FileCatalyst, NBC Sports Group selected the FileCatalyst Direct accelerated and managed file transfer software from Unlimi-Tech Software, Inc. The FileCatalyst core transport technology offered many advantages over traditional methods of file transfer, as well as advantages over other accelerated file transfer software solutions. It addressed all file transfer objectives set by NBC Sports, including the high speed transfer of event coverage over a global connection, the high speed transfer of event coverage over a regional connection, the transfer of large dynamic file sets ensuring the fastest delivery possible of the event coverage and the successful transfer of non-standard MXF files.

High Speed Transfer of Event Coverage over a Global Connection

The FileCatalyst UDP-based file transfer technology is immune to the effects of latency and packet loss on a network and guarantees file delivery, allowing FileCatalyst

Direct to quickly transfer files overseas between Sochi, Russia and Stamford, Connecticut. As latency is present in higher amounts over larger geographical distances, it was extremely beneficial that FileCatalyst Direct was able to transfer files between Sochi and Stamford without being impeded by the effects of latency.

High Speed Transfer of Event Coverage over a Regional Connection

FileCatalyst Direct's UDP-based file transfer technology also allowed NBC Sports Group to quickly transfer files between various event venues and back to the broadcast center in Sochi, with no effects of network impairments on transfer speeds. Although the event venues were closely situated, even small amounts of latency and packet loss can have a large effect on the maximum attainable speed of TCP transfers. FileCatalyst Direct was not affected by impairments on these links.

Transfer of Large, Dynamic File Sets

FileCatalyst Direct was able to address the specific requirements of transferring large, dynamic file sets, which was not available in other solutions under consideration. This was accomplished by the development of a new feature to handle the extreme concurrency in the transfer of growing files. Based on NBC Sports' requirements, Unlimi-Tech Software Inc. implemented a dynamic pool of connections between the FileCatalyst HotFolder and FileCatalyst Direct Server applications, as illustrated in Figure 1. The pool of connections was able to grow and shrink as needed, up to a maximum value as defined by NBC and only limited by available hardware and bandwidth constraints. A directory scanning process was implemented to do a perpetual scan of selected directories, continually updating a work queue with new files to be transferred. As new files were added to a work queue, a work manager process intelligently distributed the work between connections in the pool. The pool was able to adjust dynamically, connecting and disconnecting as needed in response to new work being added.

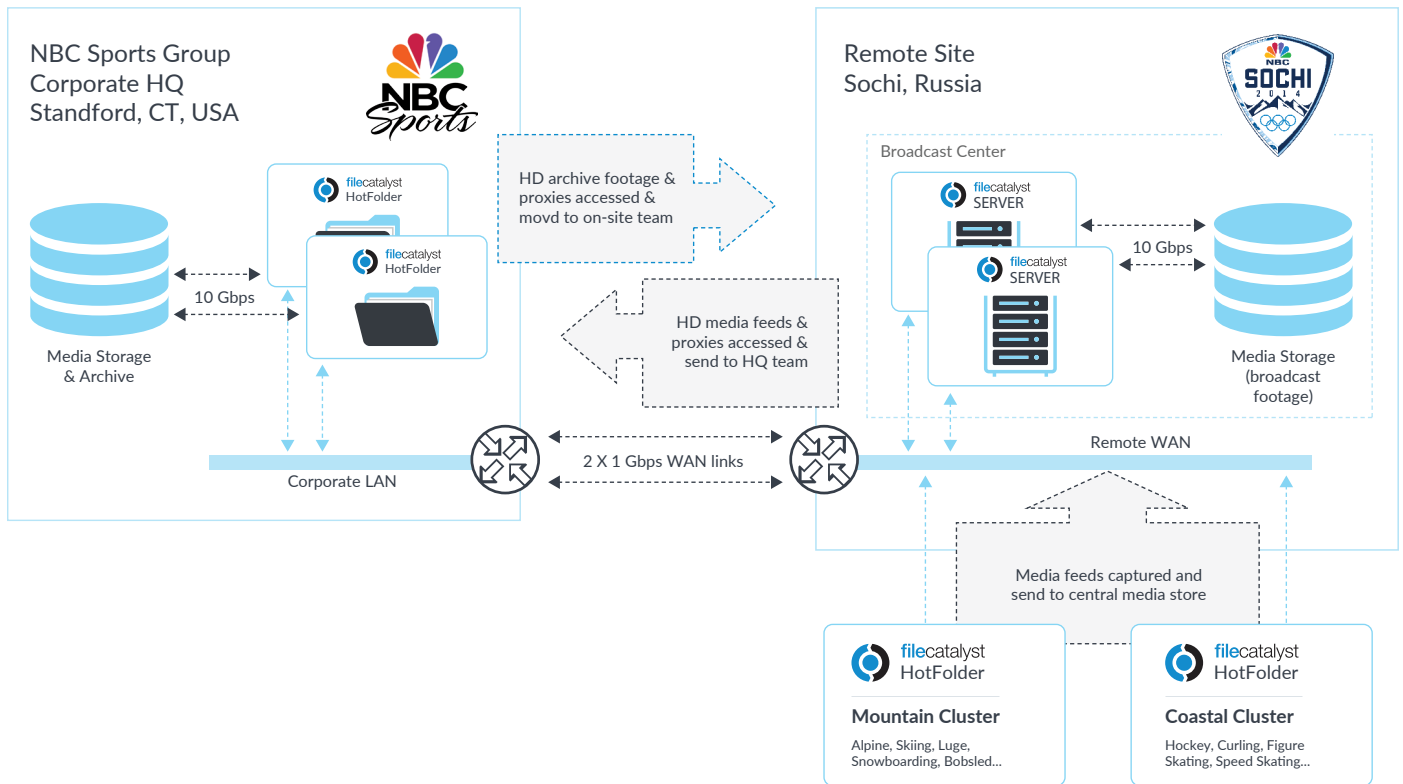


FIG 1 - REPRESENTATION OF HIGH CONCURRENCY FILE TRANSFER IN FILECATALYST DIRECT

Successful Transfer of Non-Standard MXF Files

Facilities were added to the FileCatalyst Direct solution to accommodate the successful delivery of MXF files created in NBC Sports Group's production workflow. The ability to wait for a file to remain static for a specified period of time before considering it to be complete was added to accommodate pauses during the encoding process. The use of the MD5 checksum feature was paramount to ensure the integrity of the video files that were delivered.

Implementation

To ensure maximum efficiency of file delivery for in-studio editing, NBC Sports used 3rd party editing tools and video servers to create lower resolution proxy versions of the video footage that could be sent faster than full high-resolution videos, which could be as large as 100 GB.

These smaller proxy video files, ranging from 5 to 10 GB, were then transferred back to the studios in Stamford for editing, logging and archiving. When editors in the studio created a clip from the proxy, the edit decision list (EDL) was then sent back to the remote venue where the video server created a high-resolution clip from the full high-resolution file, using the timecodes that were generated in the studio. A high-resolution video containing the required time slices was then created and downloaded. The process provided incredible time savings as the full high-resolution file never needed to be transferred.

FileCatalyst Direct accelerated the transfer of these proxy videos, as well as the selected high resolution video clips, for remote editing. As several of these proxies were being sent and worked on simultaneously, FileCatalyst Direct was able to monitor several folders for these video files and start transferring up to a hundred or more at once.

The way these video files were created allowed them to start small and grow as they were encoded. As FileCatalyst was able to start transferring the digital content as it grew, it meant that by the time the video was finished recording, it was already almost completely transferred to its destination.

Leading up to the Winter Games, NBC Sports first performed a live test of FileCatalyst Direct, using it to transfer Sunday Night Football coverage. This was followed by use at several regional and national skating competitions for Skate America broadcasts. Once it was ensured that the solution met NBC's file transfer objectives, it was confirmed that FileCatalyst Direct would be the technology behind all file transfers taking place for event coverage of the Winter Games.

To deploy FileCatalyst Direct as the main file transfer solution for the Winter Games coverage, the FileCatalyst Direct Server was installed at NBC Sports Group broadcast location in Sochi to act as the hub of all file transfer activity. FileCatalyst HotFolder was installed in Stamford to monitor the FileCatalyst Direct Server for new content to be downloaded, as well as to monitor the local video servers for new content to be pushed back to Sochi. FileCatalyst HotFolder was also deployed at each event venue in Sochi and configured to send event footage back to the Sochi Broadcast Center as soon as it was available. This deployment is fully illustrated in Figure 2.

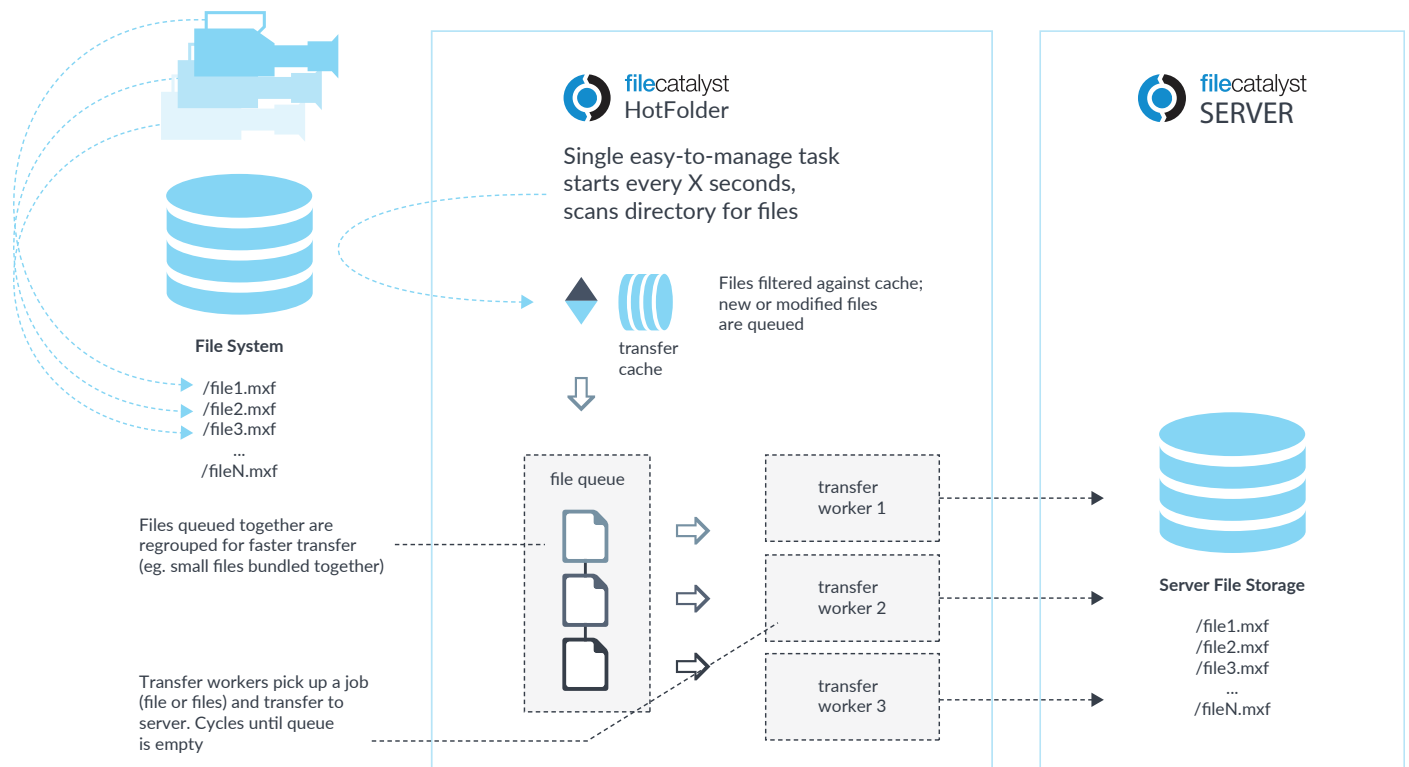


FIG 2 - NETWORK DEPLOYMENT TOPOLOGY OF FILECATALYST DIRECT FOR NBC SPORT GROUP'S 2014 OLYMPIC GAMES PRODUCTION WORKFLOW

Conclusion

In order to perform remote editing, logging and postproduction from Stamford, Connecticut and efficiently retrieve archived footage for broadcast of the 2014 Winter Olympic Games in Sochi, Russia, NBC Sports Group required an accelerated file transfer solution meeting a specific set of objectives. These objectives included the high speed transfer of video files over a global connection, the high speed transfer of video files over a regional connection, the transfer of large, dynamic file sets and the successful transfer of non-standard MXF files. Unlimi-Tech Software Inc. worked with NBC Sports to address these specific objectives and challenges for several months prior to the Winter Games. The end result was the deployment of FileCatalyst Direct, an accelerated and managed file transfer solution with a feature set tailored specifically for the live sports event production workflow involving remote editing and post-production.

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