Windows Server
Internet Information Services 7.0

Live and On-Demand Video with Silverlight and IIS Smooth Streaming

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Introduction

Viewing video on the World Wide Web has never been more popular. Whether people are watching movies, episodes of television programs, and live events, or creating and distributing video to friends using social networks, the demand for watching video over the Internet is enormous. This demand will only continue to grow as technology improves and network bandwidth increases. As demand increases, customers expect the same high-quality audio and video playback that they have with their televisions.

While this growth creates business opportunities for media companies, content delivery networks, and others in the business of delivering video online, it also creates unique technical challenges of providing that content over a heterogeneous network with fluctuating bandwidth conditions. Many earlier Internet video delivery technologies fall short of these challenges in one way or another. These are the reasons Microsoft created the Smooth Streaming and Live Smooth Streaming extensions for Internet Information Services (IIS) 7.0.

IIS Smooth Streaming is designed to deliver a compelling, uninterrupted streaming experience to viewers regardless of their network connectivity and computer capabilities.

The Challenges Associated with Current Online Video Delivery Technologies

To understand the benefits that the IIS Smooth Streaming extensions provide, you must first fully understand the technical challenges that face the commonly used approaches to delivering video over the Internet today. Customers now expect Web sites to provide video, and the only way to differentiate your sites from competitors' sites is the quality of the video experience that your site can deliver. However, providing such a high-quality experience is challenging because of the nature of the Internet itself.

There are two main challenges for online video delivery:

- Bandwidth across the network is not consistent. Users in an enterprise environment may have high-bandwidth connections with reliable throughput, while home users may have connectivity ranging in bandwidth from 56kbps dial-up at the low end to upwards of 25Mbps, all with varying reliability and throttling. End-user bandwidth changes due to Internet or local network congestion can also reduce users’ effective bandwidth, which can cause a high-speed connection to deliver content much more slowly than it typically would.
- There is no way to predict the hardware capabilities of an end-user's computer before the video reaches the requesting browser.

Traditional online video delivery technologies each have their benefits for given environments, but none of them fully address these bandwidth and client computer challenges. The following sections cover the details of each of these approaches.

Progressive Downloads

One of the most common ways you can deliver video on the Web is progressive download, which is a simple file download from an HTTP Web server. Progressive refers to the technique used by player clients that enables end users to play the video file while the download is in progress—even before the entire file is written to disk. Because the file is downloading as the client plays it, if end users pause the video during playback and wait, the HTTP Web server will continue to transfer the download until it is complete. This enables the client to then play the entire video from the browser cache without any pauses for buffering or other playback stalls.

The downside to progressive downloads is that once you have started the download, you have committed the bandwidth for the entire file. Most user-generated content is delivered using progressive download and is about five minutes in duration. However, users frequently click away after watching as little as 20 seconds worth of content, and by that time they may have already downloaded the entire file. This means that the content provider has delivered—and been charged for—over four minutes of content that will never be viewed. Additionally, if the file to download is large, it can take a long time to complete over a low-bandwidth connection.

Single Bit Rate Streaming

Single bit rate streaming is a common approach that provides users with multiple links on a page so that they can select which bit rate corresponds to their bandwidth speed. Typically, the options are:

- High for users with high-bandwidth connections.
- Medium for users with more limited bandwidth connections.
- Low for users with dial-up connections or other very low-bandwidth connections.

Content providers must encode multiple versions of the same video file for each bandwidth level they support. Most users do not know what their current average bandwidth is, and will typically pick the high-quality stream. As a result, they will frequently receive a sub-optimal experience plagued by constant rebuffering. Users that choose another option may receive a lower quality stream than they might otherwise be able to experience.

Single bit rate streaming requires a specialized server, such as Microsoft Windows Media® Services, to serve the video content to the client. The server sends the encoded video to the client in a series of data packets. There are two major limitations to this approach:

- The server sends the video to the client only at the rate at which you encoded the video. For example, if you encode a video at 1000 kilobits a second (kbps), the server streams that video to clients at 1000 kbps. If bandwidth conditions deteriorate while the user is streaming the video, playback can stall, start, and stall again while the content is rebuffered. Once the user begins the stream, there is no way to adapt the bit rate for current bandwidth conditions.
- The server only sends ahead enough data packets to fill the client buffer. The client buffer is typically between one and ten seconds (the Microsoft Windows Media Player and Silverlight default buffer length is five seconds). This means that if you pause a streamed video and wait

ten minutes, still only approximately five seconds of video will have downloaded to the client in that time. This means that users will still be subject to any bandwidth constraints when they resume playing the video, which is different from the progressive download scenario.

Multiple Bit Rate Streaming

Multiple bit rate (MBR) streaming enables media servers to send content encoded at multiple bit rates to clients in a single stream. Each encoded stream within the MBR stream is a discrete, user-definable audio and video stream and originates from the same content. This approach allows the media server and client to respond to changing bandwidth conditions dynamically. When a client connects to the media server to request an MBR file or broadcast stream, the server only sends the set of audio and video streams that is the most appropriate for current bandwidth conditions. The process of selecting the appropriate stream is completely transparent to the user.

Some of the limitations of MBR streaming are:

- It does not support progressive downloads.
- It requires you to serve media content from specialized media servers, such as Windows Media Services or Flash Media Server.
- By default, Silverlight selects the highest available bit rate, and will not adapt to any subsequent changes in bandwidth or local computer conditions.

Multicast Streaming

Multicast streaming is commonly used in enterprises or over other private networks. Multicast streaming takes advantage of a one-to-many relationship between a streaming server, such as Windows Media Services, and the clients receiving the stream. This is analogous to broadcast television: a single transmitter sends out a signal, which is received by all televisions. With a multicast stream, the server streams to a multicast IP address on the network, and clients receive the stream by subscribing to the IP address. All clients receive the same stream and do not have control of content playback. Because there is only one stream from the server regardless of the number of clients receiving the stream, a multicast stream requires only as much bandwidth as a single unicast stream containing the same content. Using a multicast stream preserves network bandwidth and can be useful for a large number of users, especially on low-bandwidth local area networks.

While viable in a closed multicast-enabled network environment, such as an intranet in an enterprise or a dedicated cable operator's network, multicast streaming is largely unsupported across the Internet.

Proprietary Streaming Protocols

Proprietary streaming protocols are the traditional way that video streaming has been done over the Internet and enables clients to start and stop the video as they wish. Typically, a company creates or extends one or more protocols to work with its streaming server and client, such as Windows Media customizations of RTSP (MS-RTSP) and HTTP (MS-WMSP), various versions of the Real Time Messaging Protocol (RTMP) from Adobe Systems, or the Real Data Transport (RDT) protocol from RealNetworks.

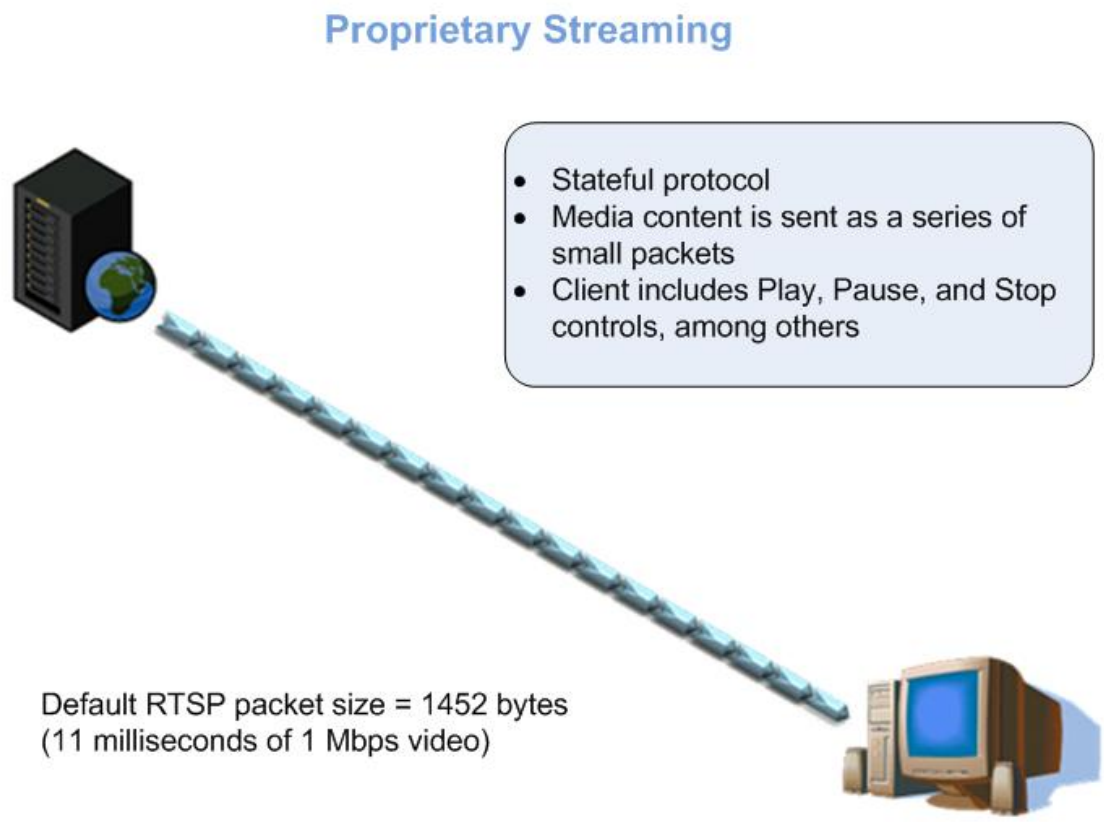

Figure 1. *RTSP is an example of a proprietary streaming protocol.*

The most important things to remember about typical delivery with proprietary streaming protocols:

- The server sends the data packets to the client at a real-time rate only—that is, the bit rate at which the video is encoded. For example, if you encode a video at 500 kilobits per second (kbps) the server streams it to clients at approximately 500 kbps.
- The server only sends ahead enough data packets to fill the client buffer. The client buffer is typically between one and ten seconds (Windows Media Player and Silverlight default buffer length is five seconds). This means that if you pause a streamed video and wait ten minutes, still only approximately five seconds of video will have downloaded to the client in that time.

The problems with these proprietary approaches are:

- They typically require specialized server software. This can make it difficult to scale for a large live event or for an anticipated large amount of streaming requests for an on-demand file for which you believe there will be a great deal of demand.
- Though highly effective when the bandwidth of a user's connection to the Internet is high, these streaming protocols do not respond well when bandwidth is limited. If the buffer runs out over a

low-bandwidth connection, the playback may pause while the server fills the buffer again, making the end-user experience frustrating.

- They usually use specific network ports, which must be explicitly opened to allow streams to travel through firewalls and routers.

Adaptive Streaming

A new technology, called adaptive streaming, addresses many of the challenges that face other video distribution technologies. Adaptive streaming is an advanced technology that uses HTTP rather than a new proprietary protocol. It is a hybrid delivery method that behaves like traditional streaming but is based on HTTP progressive download.

An Overview of Adaptive Streaming

In a typical adaptive streaming implementation, you cut the video source into many short segments, called chunks, and encode them to your desired delivery format. Typically, you make your chunks one to three seconds long.

An HTTP Web server hosts the encoded chunks and a client requests the chunks from the server in a linear fashion and downloads them using plain HTTP progressive download. As it downloads the sequence of chunks, the client plays them back in the order that it requested them. Because the chunks are carefully encoded without any gaps or overlaps between them, the chunks play back as a seamless video.

You create the adaptive part of the solution when you encode the media source at multiple bit rates, generating multiple chunks of various sizes for each chunk of video. The client can now choose between chunks of different sizes, each containing media at a different bit rate. Because Web servers usually deliver data as fast as network bandwidth allows them to, the client estimates the user's effective bandwidth and downloads larger or smaller chunks a few seconds ahead of time based on its estimates.

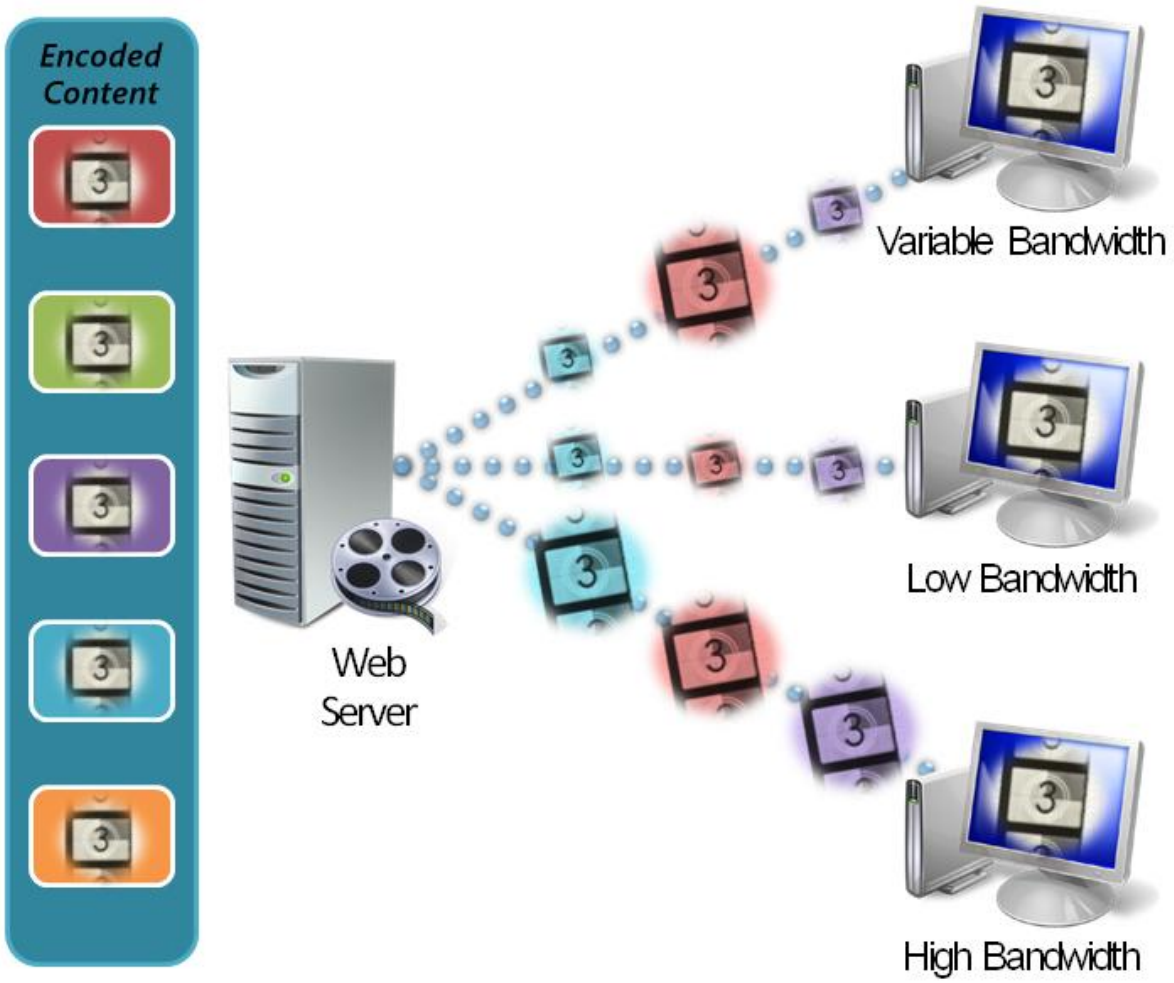

Figure 2. *Adaptive streaming is a hybrid media-delivery method.*

The Advantages of Adaptive Streaming

Adaptive streaming offers many advantages over traditional streaming to content producers and content delivery networks:

- It enables you to offer a compelling video experience to all users regardless of their bandwidth, because it can dynamically adapt to inferior network conditions; for customers with sufficient bandwidth, you can offer true high-definition (HD) video.
- It is cheaper to deploy, because adaptive streaming can use standard HTTP caches and proxies and therefore does not require specialized servers at each node. Using HTTP caches enables you to keep the content as close as possible to customers across the globe.
- It enables you to take advantage of your existing Web server infrastructure to scale quickly and easily for large live events or popular on-demand videos.

- It enables your media delivery system to transparently adapt to the conditions of each audience member, rather than requiring you or your users to guess which non-adapting bit rates are most likely to play back well.

Adaptive streaming also offers the following benefits for the end user:

- It provides a generally consistent, smooth playback experience, without requiring any user interaction.
- It enables fast start-up and seek times, because the client can initiate those actions on the lowest bit rate and then move to a higher bit rate.
- It does not buffer or disconnect from the video source and does not stutter during playback as long as the user meets the minimum bit rate requirements.
- It switches from one video bit rate to another seamlessly, based on network conditions and CPU capabilities.

Creating Chunks of Content

Since adaptive streaming technologies work by switching between chunks of content, it stands to reason that the original content must be encoded at different bit rates and divided into chunks, a process called chunking. One approach is to pre-chunk all the content, whether it is an on-demand content or a live feed, prior to uploading it to a Web server.

This step introduces a number of complexities:

- Pre-chunking creates a full step that must be included in the production environment when you host a live event or premier video content, such as a movie in high definition.
- Pre-chunking for each bit rate generates thousands of files to upload and manage on your Web server, which is inherently challenging.
- The chunking process can introduce additional delays (latency) for live events.

Microsoft took a different and unique approach to adaptive streaming, which is unique in that it delivers all the benefits without the drawbacks discussed above. This approach is called IIS Smooth Streaming.

IIS Smooth Streaming

IIS Smooth Streaming and IIS Live Smooth Streaming are the Microsoft implementations of adaptive streaming. Microsoft released each as an extension for Internet Information Services 7.0, and they are available as part of a convenient set of media delivery tools called IIS Media Services. You can easily download and install them using the Microsoft Web Platform Installer by visiting the IIS Media Services Web site.

Many companies in the community of Internet media and content providers have developed solutions that deliver video content by using chunked HTTP delivery. As an example, NBC Sports used chunked HTTP from Microsoft to deliver a rich online experience of the 2008 Beijing Olympics in Microsoft Silverlight, resulting in the broadcast of over 5,500 hours of live and on-demand streaming content and

in excess of 1.3 billion page views, 50 million unique visitors, and 10 million hours of viewer-watched video.

After this success and subsequent technology innovations, NBC Sports announced its intention to use Silverlight and IIS Smooth Streaming for all of its high-quality online video delivery across its numerous sporting franchises. Examples include NBC Sports Sunday Night Football Extra for 2009 and the 2010 Winter Olympics.

Microsoft is a leader in adaptive streaming events and building out a broad media streaming ecosystem. Many content delivery networks (CDNs) and online media delivery companies use IIS Smooth Streaming or IIS Live Smooth Streaming in their production environments. For a partial list of companies who have created smooth streaming solutions, visit the IIS Media Showcase.

Advantages of IIS Smooth Streaming

There are many benefits to choosing IIS Smooth Streaming and IIS Live Smooth Streaming to serve video content over the Internet.

- Both extensions are part of the Microsoft platform and are supported fully by Microsoft. You can use either IIS 7.0 on Windows Server 2008 or IIS 7.5 on Windows Server 2008 R2 to deliver HD-quality video content to your users.
- You have the full support of Microsoft tools and guidance to create IIS Smooth Streaming projects.
- You can use tools you are comfortable with to manage and deploy your media sites. You can use IIS Manager locally or remotely, as well as WMI or PowerShell scripts to automate any task your media site requires.
- You can easily add the functionality to your existing Web infrastructure, making it quick to scale for large live events or for launching popular on-demand media.

IIS Smooth Streaming Implementation Options

IIS Smooth Streaming can be applied to both on-demand and live content.

On-Demand Streaming

This adaptive streaming approach is supported by the IIS Smooth Streaming extension. It works as described in the How IIS Smooth Streaming Works section of this white paper. The workflow for this type of IIS Smooth Streaming begins with an existing video file. You encode this source content at several quality levels, typically with each level in its own complete file, using Microsoft Expression® Encoder 3 or your preferred third-party hardware or software compressor (see a list of compatible third-party hardware and software compression products on the IIS Media Showcase.) The encoded content is delivered using an IIS server running the IIS Smooth Streaming extension.

IIS Smooth Streaming provides media companies with a better way to make full HD on the Web a reality. It offers code-free deployment and simplified content management for content creators and content delivery networks.

Live Streaming

IIS Live Smooth Streaming is another IIS 7 extension, which is also part of IIS Media Services. It enables adaptive streaming of live events to IIS Smooth Streaming clients. Using HTTP to deliver live events takes advantage of the scale of existing HTTP networks, keeps content close to the end user, and makes true HD (720p+) a realistic option for live Web broadcasts. The additional advantage of using HTTP-based delivery for live events is that the existing HTTP infrastructure of the Internet also drastically increases live event availability.

How IIS Smooth Streaming Works

IIS Smooth Streaming experiences are easy to create and deploy by using tools available from Microsoft. For this example, we will show how on-demand content can be prepared for IIS Smooth Streaming. The first step is to encode the videos and create the Silverlight player that you want to deploy. Microsoft Expression Encoder 3 includes several preset encoding settings specifically for IIS Smooth Streaming.

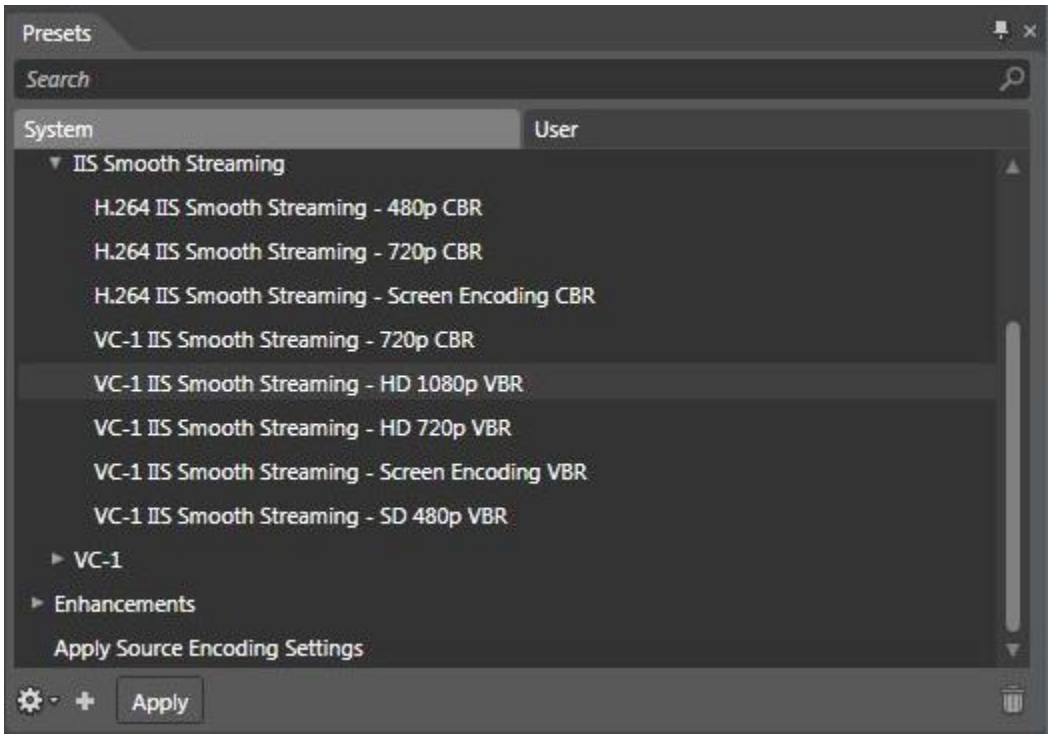

Figure 3. *Expression Encoder Smooth Streaming Presets*

It also includes a host of player templates that define the Silverlight output. You can modify any settings for the encodings or templates as required before you encode the media file, but this is not required.

If you want to modify the Silverlight player from Expression Encoder, you can do that in Expression Blend or Microsoft Visual Studio® 2008. When you complete your modifications, you simply save the project.

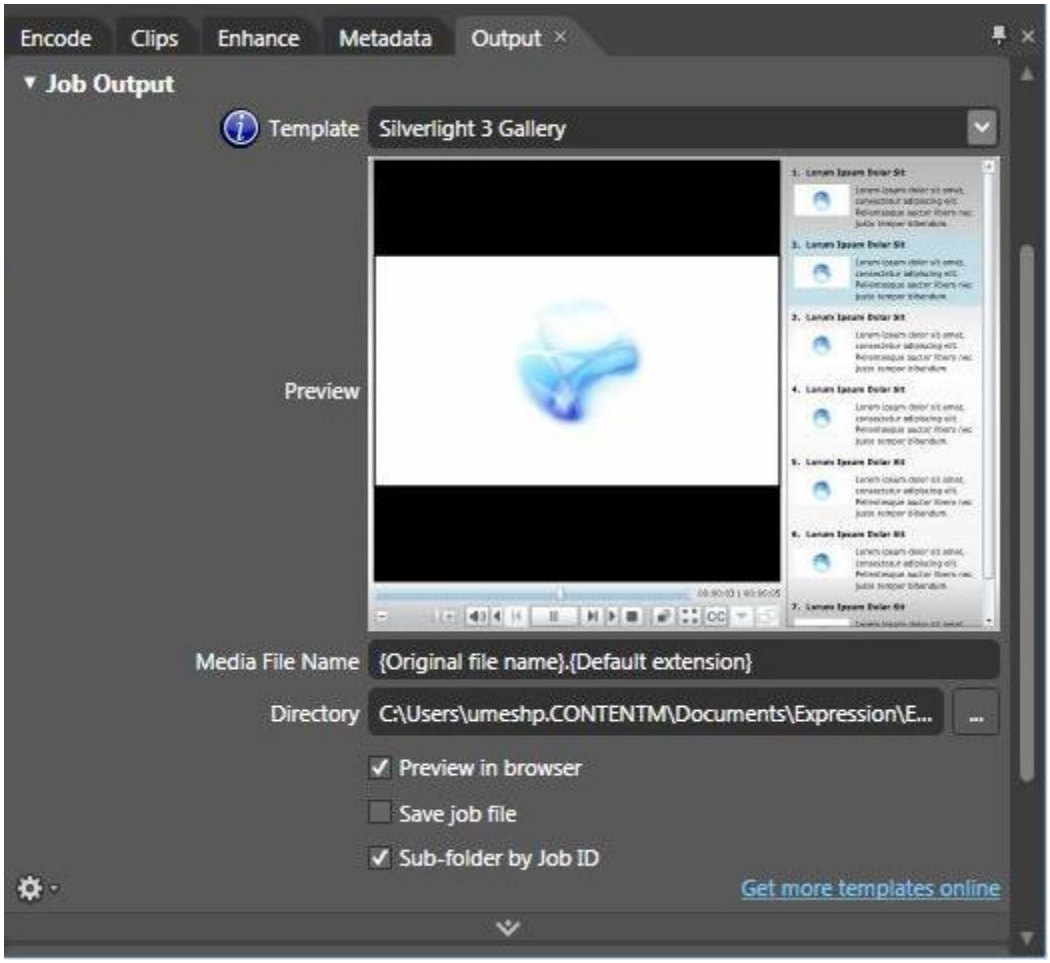

Figure 4. *Expression Encoder Silverlight output gallery*

After you encode the video in Expression Encoder 3.0 and make any modifications to the Silverlight project, you upload each output file to your IIS 7.0 or IIS 7.5 server. IIS Smooth Streaming uses a fragmented MP4 container (MPEG-4 Part 12 (ISO/IEC 14496-12) as its storage and transport format. Specifically, the IIS Smooth Streaming specification defines each chunk/GOP as an MPEG-4 Movie Fragment and stores it within a contiguous MP4 file for easy random access. This means that you only have to deploy and manage a maximum of one file per bit rate for each video resource that you want to offer for viewing over the Internet. Expression Encoder also provides the option to combine all video bit rates into a single file.

The use of contiguous video files rather than thousands of chunks dramatically simplifies file management on the IIS Web server. This is just one of the many advantages that IIS Smooth Streaming has over other adaptive streaming solutions.

When a client, such as a Silverlight player generated by Expression Encoder, requests an IIS Smooth Streaming video, it checks the effective bandwidth and current CPU conditions to determine which bit rate to request from the server. As those conditions change, the client requests fragments at different bit rates (quality levels). If bandwidth and CPU conditions improve, the client requests higher bit rate video, and if conditions degrade, the client requests lower bit rate video. This switching is seamless and practically unnoticeable to end users.

Customers can also move the playback location forward or backward in the video. In this case, the client requests a specific source time segment from the IIS Web server, then the server dynamically finds the appropriate Movie Fragment box within the contiguous MP4 file and sends it as a standalone file, thus ensuring full cacheability downstream.

What Customers Are Saying About Smooth Streaming

Many content providers have chosen to use IIS Smooth Streaming and Silverlight to deliver on-demand video and live events over the Internet. Some high-profile customers are France Télévisions Interactive, which broadcast the 2009 French Open over the Web using IIS Live Smooth Streaming, and NBC Sports, which used the technology to broadcast the 2009 Wimbledon Championships, 2009 NFL Sunday Night Football to United States audiences over the Web, and the 2010 Winter Olympic games from Vancouver, British Columbia.

"The HD broadcast of Roland Garros (the French Open) shown on our websites (www.france2.fr and www.france3.fr) was successful. For two weeks, nearly 140 000 users have watched this HD broadcast with an amazing record time of 64 minutes on average viewing per user and per day for a total of 290 000 hours available in HD."

Laurent Souloumiac, CEO of France Télévisions Interactive

"NBC Sports is committed to bringing our viewers premier sporting events such as the Association of Volleyball Professionals (AVP) events, the Wimbledon Championships and the Olympic Games. NBC Sports has evaluated many different technologies for delivering high-quality experiences online, and none have delivered the video quality, scalability and business value that Microsoft Silverlight has consistently brought. As we look forward to the 2010 Olympic Winter Games in Vancouver as well as other major championships in 2010, we will be using Silverlight as the preferred technology to deliver the best in next-generation online high-definition video experiences."

Perkins Miller, SVP Digital Media, NBC Sports

Summary

IIS Smooth Streaming with Silverlight lets you offer HD-quality video to Internet users who have high bandwidth connections, while also providing users with lower bandwidth connections a compelling, uninterrupted video experience. By using IIS 7 or IIS 7.5 Web servers, you can take advantage of your existing Web infrastructure to quickly scale video servers, and you can use HTTP caches and proxies that

already exist to ensure that content is as close to customers as possible regardless of where they live in the world.

Based on HTTP progressive download technology, IIS Smooth Streaming is easier to manage and less expensive to deploy than other traditional and adaptive streaming delivery technologies. Additionally, the Silverlight client that is used in an IIS Smooth Streaming solution monitors both bandwidth and local video playback conditions on the customer's computer, and constantly adapts to provide the highest-quality video for the current conditions. This ensures that your customers have a smooth, consistent playback experience.

To view IIS Smooth Streaming in action, see the Experience IIS Smooth Streaming demonstration on the IIS site. Next, see Serving Media Content to learn how easy it is to deploy and manage an IIS Smooth Streaming solution. To get started with testing it on your own IIS server right now using a sample player and content from Microsoft, read the Smooth Streaming Deployment Guide.

If you are an IIS developer and want to create IIS Smooth Streaming solutions for your organization, use the Microsoft Web Platform Installer and click **Install** to automatically install and configure IIS Smooth Streaming as part of IIS Media Services in your Web development environment.

Finally, see examples of how content development and delivery companies are using IIS Smooth Streaming to offer high-quality offerings for their customers. For more information, see the IIS Media Showcase.

For More Information

Media on IIS 7.0	http://iis.net/media
Serving Media Content Documentation	http://learn.iis.net/media
Microsoft Silverlight—Media	http://www.microsoft.com/silverlight/overview/media.aspx
Microsoft Expression	http://www.microsoft.com/expression
Silverlight Developer Center	http://msdn.microsoft.com/silverlight
Microsoft Silverlight Community	http://silverlight.net/community/

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