

Video Streams into the Mainstream

George Lawton

The widespread adoption of streaming video on the Internet appears ready to become the next major frontier for online multimedia.

Graphics, animation, and audio technologies have already proliferated on the Internet. However, streaming video—in which viewers can begin watching content almost as soon as it starts downloading—is only now developing as a mainstream technology.

“In the past 18 months,” said Alex Benik, an analyst with the Yankee Group, a market research firm, “streaming video has evolved from being a toy to something that service providers of all kinds can hope to generate revenue from.”

The Gartner Group, a market research firm, estimates that the portion of US companies using streaming media has almost doubled, from 9 to 17 percent, since last year.

Benik said two of the key factors driving this trend are the increasing adoption of broadband services that speed Internet access for users and the development of backbone networks that speed the delivery of content by providers.

In the past, video has been too data intensive for most users. However, the growing use of broadband technologies has spurred the rapid growth of streaming media, according to Martin French, vice president at MeTV.com, a streaming-video content provider. “A year ago,” he said, “the only people with fast Internet access were with companies with T1 lines. Now we are seeing an awful lot of people



with [asymmetric digital subscriber lines (ADSL) service] and cable modems.” People are also using broadband fixed-wireless and satellite technologies for Internet access.

In addition to spurring consumer applications, streaming video also promises to fuel corporate applications over intranets and extranets to support distance learning and training, corporate communications, marketing, and advertising.

In fact, said analyst Cushing Anderson of IDC, a market research firm, streaming video will help drive sales of distance-learning applications from \$1.1 billion in 1999 to \$7.1 billion in 2002.

A number of companies provide streaming-video technologies, but the major players are Apple’s QuickTime, Microsoft’s Windows Media, and Real Networks’ RealVideo.

VIDEO-OVER-IP BASICS

Apple pioneered digital video technology in 1991 with the development of QuickTime, which was originally designed

for creating CD-based video applications. It is still widely used for this purpose.

However, QuickTime did not initially support streaming. Users had to download entire files before viewing them, thereby restricting online video to die-hard hobbyists with either fast Internet connections or a lot of free time.

Several years later, companies began releasing commercial streaming-video technologies. Some of the early vendors included VDOnet (which stopped selling its software earlier this year), VxTreme (since acquired by Microsoft), and Progressive Networks (which changed its name to RealNetworks).

The most important technological advance that enabled streaming video was the development of technology for buffering and managing the flow of data as it arrives on the client. Now, the client sets up a TCP or UDP connection with the server and requests that content be streamed into the client’s buffer. The content is then managed by the player and streamed from the buffer.

This permits streaming-video servers to send compressed files in a continuous stream over the Internet, an intranet, or an extranet. The user views content in a player, which decompresses streaming files and sends video data to the visual display and audio data to the speakers. There are stand-alone players and those that users can integrate into a browser as a plug-in. QuickTime, RealPlayer, and Windows Media can work both ways.

Servers can distribute streaming video on demand from prerecorded files or as a live broadcast feed. With live video, servers must be multicast-enabled so that they can efficiently send content to multiple viewers at the same time. Figure 1 shows how this works.

A typical 56-Kbps modem connection can provide only the traditional small video window because it doesn’t have enough bandwidth to support the amount of data necessary to fill a larger screen.

However, broadband Internet-access products and better compression/decompression (codec) technologies will let users take advantage of the newer streaming-video approaches that deliver full-screen video at 500 Kbps and even higher quality video at 1 Mbps.

By and large, only users with T1 or fiber connections can currently take advantage of these technologies.

Theoretically, cable modems offer a maximum transmission speed of 10 Mbps, while DSL modems offer up to 1.5 Mbps. But in practice, consumers typically receive only 200 to 300 Kbps of sustained throughput, so they generally can't make full use of the new streaming-video technologies, according to Ben Rotholtz, RealNetworks' general manager of products and systems. However, he said, cable and DSL carriers are expected to deliver 600 to 900 Kbps as they upgrade their networks.

KEY PRODUCTS

The three most popular streaming-video products are Apple's QuickTime 4 (which has been integrated into the MacOS but which can also be downloaded separately), Microsoft's Windows Media 7 (which has been integrated into Windows but which can also be downloaded separately), and RealNetworks' RealVideo 8 (which runs on the company's RealPlayer).

The basic clients are free, although Apple and RealNetworks also sell enhanced clients.

Microsoft also sells NetShow Theater Server, a high-end product that delivers full-screen, broadcast-quality video over high-bandwidth networks. NetShow is primarily designed for use over high-speed LANs and intranets, and its content can be run on a standard Windows Media player.

Users can access small-screen, lower quality video from all three streaming-video products with 56-Kbps and even slower modems. However, users who want high-quality video must be able to access the Internet at 500 Kbps for RealVideo 8, 700 Kbps for QuickTime, 720 Kbps for Windows Media 7, and up to 8 Mbps for NetShow. The difference in access requirements is based on the products' different codec algorithms.

Platform support

The QuickTime streaming server supports the FreeBSD, Linux, MacOS, Solaris, and Windows operating systems. The RealVideo server supports the Linux, Solaris, and Windows operating systems.

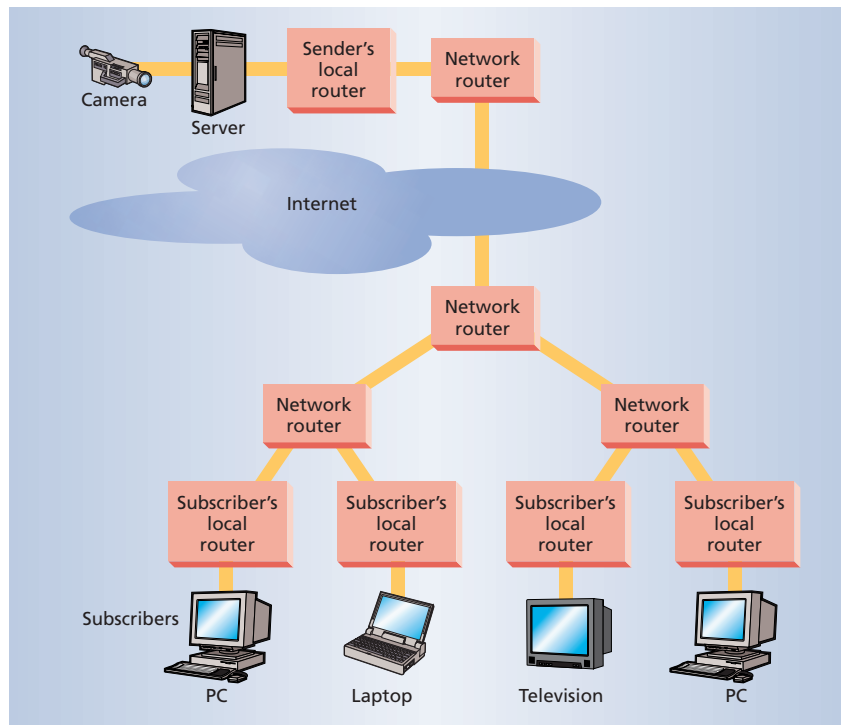


Figure 1. A live streaming-video feed uses multicasting to send files to multiple viewers at the same time. The camera shooting the live scene sends its video and audio feeds to a server, which then distributes the data as a single stream into the Internet. With multicasting, the data is maintained as a single stream until it gets close to the recipients, at which point it is copied and redistributed. This avoids the bandwidth consumption that would occur if a different data stream had to be sent from the server to each recipient. Multicasting also helps with scaling.

Both technologies' clients support all major platforms.

The Windows Media server runs only on Windows, while the client supports only the Macintosh and Windows platforms.

Advantage to QuickTime

QuickTime is the oldest of the online video technologies. According to Frank Casanova, Apple's director of QuickTime product marketing, the product is supported by more applications, including even Microsoft Word and Excel, than competing technologies.

Advantage to Windows Media

One advantage of Windows Media is that it is integrated with other Windows-based technologies. This makes it simpler to implement and utilize for some Windows users, especially those without significant technical experience.

Windows Media also includes digital-rights management technology, which protects content providers' intellectual property. The technology lets content owners prevent recipients from distributing material without the author's permission.

Content producers are concerned about unauthorized distribution of their material. Therefore, streaming-media companies want to convince producers that it's safe to provide quality content for Windows Media.

Advantage to RealVideo

An advantage of RealVideo is that content providers can encode files so that clients can access them at different speeds. The client can then select the best access rate based on the available bandwidth.

BATTLE IN THE MARKETPLACE

The streaming-video market pits Real-

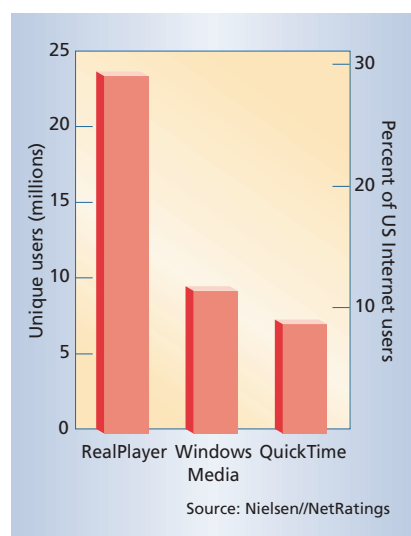


Figure 2. Of the major commercial streaming-media technologies, RealNetworks' RealPlayer has the biggest US market share by far, followed by Microsoft's Windows Media and Apple's QuickTime.

Networks, a company whose only business is media, against Apple and Microsoft, which have other business interests.

As shown in Figure 2, RealPlayer has 23.5 million unique users, representing 29.41 percent of the 80 million US Internet users; Windows Media Player has 9.4 million users, representing 11.75 percent of users; and QuickTime has 7.2 million users, representing 8.98 percent of users, according to a survey conducted this year by Nielsen//NetRatings, a company whose activities include the measurement of Internet-related audiences.

To advance their positions, Microsoft and RealNetworks have purchased and invested in other streaming-video companies. And both companies, as well as Apple, are working with providers to develop compelling content for their technologies.

Microsoft is concentrating on developing Windows Media technology and integrating it into Windows. Apple and RealNetworks, on the other hand, are trying to increase marketplace support for their products with a multipronged approach that includes media-publishing and consulting services.

Last September, Microsoft promoted its technology by forming the Windows

Media Broadband Jumpstart coalition to encourage increased adoption and improvement of video and audio over high-speed connections via Windows Media. About 100 streaming-media-related companies have joined the coalition.

Meanwhile, Apple and Microsoft have recently licensed QuickTime and Windows Media for free to RealNetworks. If RealNetworks supports the technologies, this could encourage content providers to develop more material for QuickTime and Windows Media because the content could then also be shown on RealPlayer.

The Yankee Group's Benik said that although RealNetworks is the market leader, the company is at a crossroads and must decide if it wants to be a technology innovator, a multiservice Web portal designed to attract visitors and advertising, or a broadcast services provider. He said, "I don't think they will be successful going in all three directions."

STREAMING INTO THE FUTURE

Streaming video faces several key technical and business challenges.

Technical issues

The key technical issues facing streaming video include Internet congestion, interoperability, and compression.

Internet congestion. Currently, online video is subject to transmission interruptions because of Internet congestion, particularly for users with lower bandwidth connections.

Several network service providers—such as AboveNet Communications, Digital Island, and Exodus Communications—are selling access to their high-bandwidth networks to streaming-media content distributors. This lets distributors bypass most Net congestion. In addition, some service providers, such as iBeam Broadcasting, have developed satellite distribution networks, which broadcast streaming-video signals to the edges of the Internet, again avoiding most Net congestion.

Some providers avoid congestion by using other schemes to send transmissions from the Internet's edge to recipients. For example, vendors such as GMV Network have developed proxy servers for deploy-

ment at the Internet's edge. The servers accept a video stream from a content provider's master server and duplicate it for recipients closer to the source.

In addition, telecommunications companies such as AT&T, GTE, and Sprint Communications have let RealNetworks deploy its own edge servers throughout their networks. Apple has launched a similar infrastructure for QuickTime on top of Akamai Technologies' large content-distribution network.

Meanwhile, some content providers distribute their material via multicasting, which transmits one stream of data that is copied and redistributed close to the multiple recipients. This avoids some of the problems caused by the increased bandwidth consumption that accompanies growing streaming-video usage.

Sometimes, providers can't avoid congestion. Burst.com has an application called Burstware that sends video data across the backbone in quick, large bursts for storage in a cache, which then buffers the material. If a data transmission is delayed over the network, the user can play content from the cache.

Interoperability. Streaming-video technology will need more standardization to become truly widespread. Currently, all the major streaming-video players support QuickTime.

Microsoft's Active Streaming Format (ASF) is a low-overhead, open file format for storing streaming-multimedia content. The company designed ASF to optimize content delivery and to integrate and synchronize different media types. For example, ASF enables the synchronization of images with an audio track.

RealNetworks supports ASF. However, Microsoft does not support RealVideo. These types of practices force some developers to either design content in one format, thereby losing audiences that use other formats, or spend additional time and money to develop, store, and serve content in multiple formats.

Compression. Data-compression algorithms are critical to providing quality video at lower transmission speeds, so work is continuing on better codec technologies.

Currently, Microsoft uses a slight variant of the MPEG-4 codec algorithm. In

fact, Windows Media is the only streaming-video player that uses the MPEG-4 standard, said Leonardo Chiariglione, convener of the Moving Picture Experts Group, a standards organization for digital-media codec technology.

Nielsen/NetRatings analyst Jarvis Mak said RealNetworks' two-pass encoding is currently the best compression technology. According to Mak, this technology analyzes an entire video before encoding it to determine how best to compress the video on the second pass.

This reduces the final video file size, RealNetworks' Rotholtz said, but the two passes require 15 to 20 percent more time to carry out than a single pass.

Business issues

As is the case with many technologies, vendors are trying to figure out how to make money from streaming video.

Earlier this year, RealNetworks announced profits of \$8.75 million for the

first quarter of this year. The company also reported profits for the last two quarters of 1999.

Apple spokesperson Vanessa Rios would not provide figures but did say that the company is making money from its QuickTime technology.

Microsoft did not return calls for information about whether its streaming-media operations are profitable.

Technology vendors. One way that Apple and RealNetworks hope to make money is by selling servers and services. Microsoft, on the other hand, would like to sell more of the NT servers required to stream Windows Media content. In addition, increased use of Windows Media could contribute to the increased use of the Windows OS, Microsoft's core product.

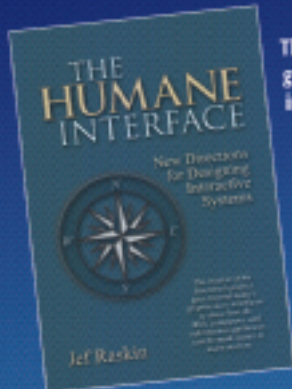
Content providers. Content providers also must determine how to make money with streaming media. Most streaming video consists of content such

as brief news clips and short films. Most providers give away their content, leaving them with only such revenue sources as advertising.

A few providers, however, such as Kanakaris Communications (<http://www.kkrs.net>) and MeTV.com are developing libraries of pay-per-view content. In fact, MeTV.com has developed a converter box that lets a computer wirelessly send audio and video to a television. MeTV.com's French said, "Streaming video will not take the place of TV, but companies like ours need to pump [content] to the TV to get people to watch it."

However, streaming-video content itself will have to be compelling for user interest in the technology to grow. "In the last six months, there has been a huge proliferation in the number of sites with video. The problem has been that no one has offered the kind of content that consumers want," said Gartner Group analyst Sujata Ramnarayan.

NEW From Addison-Wesley!



The creator of the Apple Macintosh project goes beyond today's graphic user interfaces to show how the Web, computers, and information appliances can be made easier to learn and use.

"Deep thinking is rare in this field where most companies are glad to copy designs that were great back in the 1970s. The Humane Interface is a gourmet dish from a master chef. Five mice!"
—Jakob Nielsen, Nielsen Norman Group, author of *Designing Web Usability: The Practice of Simplicity*

ACM Press • 0-201-37937-6 • 256 pages

Written by a world-renowned expert on programming methodology, this book shows how to build production-quality programs—programs that are reliable, easy to maintain, and quick to modify.

0-201-65768-6 • 464 pages



Examine these books during **SIGGRAPH** at Addison-Wesley Booth #1936.

Look for these titles wherever fine technical books are sold.

Also Available



Describes how to build and operate interactive 3D graphics online, including ways to overcome the problems and limitations in real-time interactive system development.

ACM Press
0-201-32557-8 • 352 pages

Addison-Wesley

www.awl.com/cseng/

Industry Trends

According to French, companies will have to alleviate content providers' fears about piracy and distribution control before they make more popular content available.

LOOKING AHEAD

Industry observers question whether Microsoft will overtake RealNetworks. They wonder whether the situation will turn out like the browser market, in which Microsoft's Internet Explorer caught and passed longtime leader Netscape Navigator, or like the Internet service provider market, in which Microsoft's MSN hasn't come close to catching the front-runner, America Online.

MeTV.com's French said the streaming-media marketplace battle will take place primarily between Microsoft, which wants a role in the media-intensive Internet world of the future, and RealNetworks, whose sole business is multimedia. He said QuickTime will not

Streaming Video with Java

In most streaming-video technologies, users have to download plug-in or stand-alone clients that play content that must be compatible with the client platform. However, a number of companies, such as the Geo Interactive Media Group (www.emblaze.com), are taking a different approach by developing Java applets for streaming-video content.

When downloading content that works via a Java applet, a user with a Java-enabled browser also downloads the applet. The content is then streamed through and viewed on the applet, which is then cached on the user's machine.

This approach has several advantages, according to John Graham, founder of Graham Technology Solutions (<http://www.graham.com>), which makes a Java applet and server used for streaming content from such sources as live events, scientific instruments, and satellites. For example, he said, there is no plug-in to install or update.

In addition, because the applets use Java, they can work with content developed on almost any platform, said Jarvis Mak, an analyst with Nielsen//NetRatings, a company that measures Internet-related audiences and activities.

be as important a player and will appeal primarily to Macintosh users and graphics designers.

Other vendors have tried to play an important role in the streaming-video battle but have failed because the three major

**SMU ENGINEERING**

Take a leadership role in Software Engineering.

Master of Science in Software Engineering

Be at the forefront of the next century's most important industry with a Master's degree from SMU. Our core curriculum was developed in consultation with the Software Engineering Institute, which means we offer the very best and latest innovations in the field. You'll be trained in critical software and system design principles as well as practical problems of bringing products to market. Get the competitive advantage in the new millennium.

Available nationwide through videotape distance education.

For information call 214.768.1452
www.seas.smu.edu

SMU will not discriminate on the basis of race, color, religion, national origin, sex, age, disability, or veteran status.

CISE EDUCATIONAL SOFTWARE CONTEST

If you create great educational software, you can win professional recognition, wide distribution of your software, and a \$500 cash prize!

Submission deadline: **7 August 2000**
Notification of winners: **1 October 2000**

Computing in Science & Engineering magazine wishes to recognize and reward authors of outstanding pedagogical software. Our Software Repository will give the science and engineering community a first-rate central source for finding great Web-based pedagogical software.

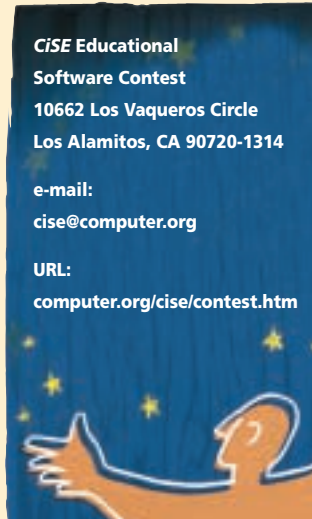
Winning entries must

- ✓ have sound scientific/engineering/technical content appropriate to university-level and continuing-education students
- ✓ present it in a pedagogically effective way (for instance, offer good ancillary material)
- ✓ accomplish something that is particularly well suited to the computer
- ✓ be freely available through the Internet (entries that run under standard Web browsers are encouraged)

GET YOUR ENTRY FORM NOW!

CISE Educational Software Contest
10662 Los Vaqueros Circle
Los Alamitos, CA 90720-1314
e-mail:
cise@computer.org
URL:
computer.org/cise/contest.htm

computing
in SCIENCE & ENGINEERING



players have not left room for another leading competitor in the market.

The Gartner Group's Ramnarayan said RealNetworks is the market leader in part because it has developed a kind of ecosystem for its technology. It has a large consumer base for its players, a large content base, and a large set of tools, with each element feeding the others, she explained.

However, said Rob Enderle, a vice president and research leader with the Giga Information Group, a market research firm, Windows Media is catching up with RealNetworks' technology. Moreover, he said, Windows Media is part of the integrated Windows platform, which means it is less complex and thus more attractive to users.

As for the technology itself, MPEG's Chiariglione said he expects it to remain largely the same in the near future, except perhaps for widespread adoption of digital-rights-management technology.

French predicted that researchers will develop better compression encoding technologies during the next two or three years, which will improve video quality. A growing trend is the use of Java applets for streaming media. (See the sidebar "Streaming Video with Java.")

Eventually, Enderle said, a range of machines, including Walkman-like devices, will incorporate streaming-media capabilities, which will bring the technology to more people.

French said, "Streaming media is the future and is coming fast. We saw music on the Internet start a few years ago as poor-quality reproductions playing only on specialist sites. Now it has become high-quality [audio] streaming over the Internet at all times today. Video on the Internet will follow the same pattern." *

George Lawton is a freelance technology writer based in Brisbane, California. Contact him at glawton@best.com.

Editor: Lee Garber, *Computer*, 10662 Los Vaqueros Circle, PO Box 3014, Los Alamitos, CA 90720-1314; l.garber@computer.org

Join the IEEE Computer Society online at

computer.org/join/

**Complete the online application
and**

- **Get immediate online access
to *Computer***
- **Sign up for a FREE e-mail alias
you@computer.org**
- **Access the CS Digital Library
for only \$50***

And that's just part of . . .

The World's Computer Society

*Regular price \$99. Offer expires 15 August 2000