EXHIBIT 5

STREAMING MEDIA TECHNICAL ANALYSIS

BURST.COM'S BURSTWARE TECHNOLOGIES

MICROSOFT WINDOWS MEDIA

EDGE CACHING

EDGE SERVING

WHITE PAPER

Produced by

APPROACH INC.

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ABOUT APPROACH

Approach is a professional services firm. Since 1989, Approach has provided integrated business solutions that unite management and technology services with Fortune 500 and mid-size clients. With expertise in management and technology consulting, Approach consultants have served leading companies in financial services, real estate, media, communications, consumer products, pharmaceuticals, and manufacturing.

Approach offers a wide selection of professional services covering B2B solutions, Digital Media, and Enterprise Systems. Approach is a recognized leader in delivering integrated digital media solutions to the Enterprise and Internet markets. Approach has been developing digital media solutions since 1997. These solutions range from enabling live audio and video content on the desktop to more complex video based collaborative solutions.

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I. EXECUTIVE SUMMARY

Streaming media is one of the fastest growing Internet technologies today. Advancements in network and storage capabilities and streaming media technologies are making it a more attractive option for entertainment, advertising and enhancing the experience of the web site users. However, there continue to be critical challenges for companies preparing for the rapid growth in streaming media. The combination of high bandwidth (300Kbps to 1 Mbps or more) media files, limited bandwidth availability, and network errors can degrade the quality of the experience of the users of streaming media.

This paper presents the analysis and results of an independent study conducted by Approach Inc. to compare the technical performance and costs of currently available streaming media technologies:

1. Conventional streaming sends a steady flow of content to the computer's player. The user views the content while the next portion is transmitted.
2. Burst-mode delivery or "bursting" uses surplus bandwidth to send large chunks of content, in excess of what is being viewed by the user, and stores the excess on the client-side cache. Bursting uses the client's cache to smooth the inconsistencies of Internet bandwidth conditions and maintain content quality.
3. Edge caching sends content to the user the same way as streaming except "thin" servers are placed in multiple geographic locations and users get the content from servers nearest to their location. The content is placed on the server when it is requested and is then available to the subsequent users.
4. Edge serving, similar to edge caching, stores a complete or partial copy of the content on servers setup in multiple geographic locations. The content is placed on the servers before it is requested, based on the popularity of the content.

A test lab, simulating real-world conditions on the Internet, was developed at Approach Inc. The lab was used to test the performance of conventional streaming compared to streaming with Burstware. The extrapolations from the results of these lab tests were used to compare edge caching and edge serving with Burstware.

The tests were based on three business scenarios:

1. An entertainment Internet service provider planning to increase their capacity for streaming.
2. An distance-learning provider planning to offer streaming media services for the first time.
3. A consumer products company planning to improve corporate communications with streaming media on their intranet.

The tests focused on narrow band, mid-range bandwidth, and broadband access. Two categories were used as the basis for the technical comparison:

- A scalability and capacity test was designed to determine how many successful media streams could be served in a given time period.
- A quality test was designed to measure the effectiveness of the technical strategies.

The total cost of ownership was calculated for implementing and maintaining conventional streaming and Burstware over a period of three years.

KEY FINDINGS

- Burstware is more scalable than conventional streaming. Due to faster, more efficient processing Burstware was able to finish transmitting the stream faster than Windows Media and therefore is able to service more client requests over time.
- In adverse network conditions, Burstware is also able to deliver a higher-quality end-user experience

than conventional streaming.

- Using Burstware in an edge serving implementation requires fewer servers than edge caching. Therefore, the cost of ownership for edge serving with Burstware was determine to be 23-26% less that edge caching.
- Burstware resolves bandwidth congestion problems by monitoring and adapting to network, client and server conditions. Burstware users play the stream from a larger client-side buffer and are thus protected from network errors.
- For centralized streaming, the total cost of ownership for Burstware was 24% less than Windows Media.
- Burstware can stream content in many different formats, eliminating the need for additional hardware and software to support multiple formats.
- Burstware has built-in load balancing which results in lower implementation costs and fewer points of failure.

II. OBJECTIVES AND METHODOLOGY

This document describes the results of a study conducted by Approach Inc. on streaming media technologies. The objective of the study was to conduct an independent, competitive analysis of the technical capabilities and total cost of ownership (TCO) for various streaming technology strategies:

- Centralized streaming with conventional streaming using Microsoft Windows Media compared to Burstware.
- Distributed streaming with edge caching compared to edge-serving with Burstware.

A technical review of conventional streaming, Burstware, edge caching and edge serving technologies was conducted as the basis for the analysis. The study focused on the application of these technical strategies to three common industry segments: entertainment, distance-learning and corporate communications. The tests focused on narrow band, mid-range bandwidth and broadband access. Approach created a test lab to simulate a real-world environment that tests capacity, scalability and quality of service of conventional streaming and Burstware technology.

III. STREAMING MEDIA MARKET POTENTIAL

Streaming media, the transmission of streamed video and audio over the Internet or corporate network to a user's personal computer, is a powerful and compelling communications vehicle and one of the fastest-growing Internet technologies today. According to Nielsen NetRatings (http://www.nielsen-netratings.com/), streaming media is accessed by over one-third of home surfers. Researchers from Dataquest (http://www.dataquest.com) expect the number of companies that have streaming media on their web sites to increase from 9% to 30% over the next year. Analysts predict that the market for streaming media on the Internet could be more than $2 billion by 2004.

The rapid growth in streaming media has been driven by Web portals, online video and audio (radio stations or Internet-only audio websites) and e-commerce sites. These web sites use streaming to deliver video and audio news and entertainment conveniently to the user, such as: CD-quality music, movie clips, television programs, sports events, fashion shows and concerts. Web sites are using streaming media to enhance the users' experience and improve "stickiness." Studies have shown that sites with streaming media keep their visitors twice as long as sites without streaming media.

Advertisers are also driving the growth of streaming media. According to Arbitron/Edison Media Research (http://www.edisonresearch.com), advertising executives are increasing their budgets for webcast advertising. Arbitron/Edison Media Research studies show that streaming media advertisements have twice the click-through rate as non-streaming ads. Their studies also show that people who watch streaming media are more likely to buy than those who don't. For example, a low-budget movie, The Blair Witch Project, became one of last summer's top grossing films partly due to a creative web marketing campaign that offered streaming video teaser segments.

MARKET SEGMENTS

Rapid growth in the use of streaming media is noticeable in the areas of entertainment, distance-learning and corporate communications.

ENTERTAINMENT

The Internet is quickly becoming the medium of choice for the latest in news and entertainment. With a few clicks, customers can view movies-clips, TV shows, sports events, advertisements, concerts, and music anytime, anywhere. Users can receive TV or radio broadcasts after they have aired. Recording artists, record labels, actors, producers, can distribute samples of their work, allowing customers to hear one song from a new CD or view a preview of a new movie.

In one year, the number of Internet users that have listened to online radio broadcasts has grown from 18% to 30%. Arbitron/Edison Media Research studies show that 18 million Americans listened to online radio in a single month and estimate that 34 million Americans have viewed video online.

DISTANCE-LEARNING

Online education is fast becoming the preferred way for older or working students to finish a degree, change careers or continue their education. The U.S. Department of Education estimates that 50% of all U.S. institutions of higher education offer distance learning, and that percentage will increase to more than 80% within three years, with much of it occurring on the Internet. For example, a large California-based university established Internet-based online education with 18 video-based courses and more than 450 registered students. After four years, they now offer over 250 continuing education or graduate-level courses to over 5,000 professionals every year. The online students are able to participate as much as students who are physically in the classroom, due in part, to the increased use of video and collaborative tools. In another example, a leading east coast provider of online learning, combines content, technology, and consulting to create electronic learning solutions. These provide both live and on-demand media and live collaboration to corporations and institutes of higher education.

Business Communications

While bandwidth management is still an important concern, advancements in streaming media capabilities, storage and network technologies are making streaming media a more attractive feature for corporate intranets.

Streaming media over a corporate intranet can deliver compelling and consistent messages to employees. Employees can view company announcements simultaneously or on-demand. Employees can view videos of product information or company news and events. Corporations can conveniently offer web-based video courses, training more employees than with traditional methods, without the costs and logistical problems of travel.

For example, a leading provider of health plans and financial services has benefited from several uses of streaming media on their internal networks. Using Microsoft Windows Media as their digital media solution, the company's president was able to communicate a very important acquisition to over 35,000 employees only two hours after the acquisition was closed. In addition, employees were able to complete self-directed training programs. The company also plans to use streaming media for customer education, public relations, knowledge management, virtual meetings and press releases.

New Challenges for Streaming Media

Streaming media is becoming a critical business application. Websites are more complex, transferring larger quantities of data to more users. Businesses require better bandwidth management, a high-quality user experience, and faster, more efficient and reliable service.

Manage Bandwidth for Extreme and Irregular Volumes

Streaming media providers are faced with problems of network congestion and low quality due in part to the extreme and irregular volume of users. Popular entertainment websites report having as many as three million visitors per month. Yahoo!Broadcast, a leading provider of video and audio news, sports and corporate events, boasts of more than 143 million visitors per month. In addition, content providers often overestimate the number of concurrent users they expect for a particular event, stating numbers in the tens to hundreds of thousands. With numbers like these, platforms must be scalable and able to support extreme peak volumes.

Streaming media providers are transmitting huge streaming media files with limited available bandwidth. With no guarantee that bandwidth will be available to their users when they need it, ISPs are led to over-providing bandwidth, paying up to ten times more than they need, to ensure bandwidth during periods of peak volumes and to satisfy demands. Much of this excess bandwidth is wasted during off-peak hours.

Increased Need for Quality and Reliability

To attract viewers to pay-per-view or pay-for-subscription services, providers of streaming media must offer high-quality, reliable service. Networks need to handle the increased streaming traffic and volume of data without forcing users to experience a loss of visual or audio quality. Better, more efficient management of available bandwidth is, therefore, an important issue for providing quality and reliable service.

Content providers require CD-quality audio and high-quality, uninterrupted, jitter-free video for their users, many of whom pay-per-view or pay for monthly subscriptions. For example, guaranteed quality and reliability is extremely important for any company planning to stream a major new product release. Distance learners who need to view a lecture before a major exam and need clarity when viewing complex equations on a whiteboard. Any business or website offering significant streaming media won't thrive without reliable 24x7x365 service.

MINIMIZE IMPACT ON NETWORK PERFORMANCE

Corporations seeking to implement streaming media on their intranets need to minimize the impact on their internal networks. Corporations have been slow to embrace streaming media internally due to quality and performance issues. Historically, streaming media reduced internal corporate network performance due to the large size of its files, impacting the experience and productivity of all network users.

IV. TECHNOLOGY STRATEGIES

There are several advances in technology that attempt to overcome the challenges of delivering real-time multimedia over large networks. Four technical strategies addressed in this study are: conventional streaming, Bursting, edge caching and edge serving.

CONVENTIONAL STREAMING

Streaming is a method of delivering multimedia in real-time to a client player that requests it. As the first few seconds of the media are played, the next few seconds (usually 5-15 seconds or less) are sent to the player and stored in a small temporary buffer until needed. This small buffer allows the stream to recover in the event of data loss during transmission. An increase in the buffer size results in an increase in the time between the user's request and the beginning of playback.

Streaming is characteristically a steady method of delivery. As long as the bandwidth between the client and server is not constrained, the stream will play at the bit rate at which the file was captured. For example, with sufficient bandwidth and ideal conditions, a 100Kbps stream will consume 100Kbps of bandwidth regardless of the bandwidth between client and server. When server-client bandwidth is constrained, either by an increase in other traffic or a malfunction, a stream will begin to "thin" or degrade in visual or audible quality. This compromise allows the user to continue to experience the media, although at a lower fidelity. When the buffer becomes depleted, and is not refilled in background, thus leading to pauses during playback.

The most common streaming technologies are RealNetworks' RealSystem, Microsoft Windows Media and Apple QuickTime Streaming.

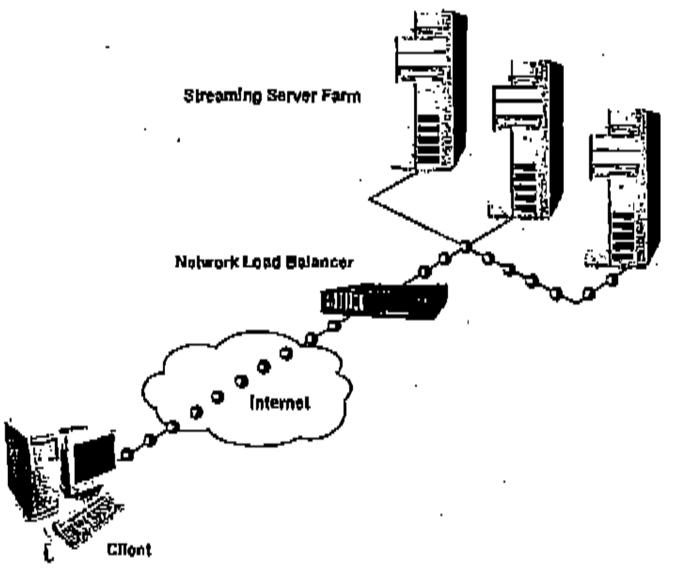

Figure 1: Sample streaming architecture

Figure 1 illustrates how centralized streaming solutions are often designed. A streaming server farm sits in some hosted position on the Internet with load balancing provided by network load balancing hardware or a software solution such as Microsoft Windows Load Balancing Service or DNS round robin. Each user uses only the bandwidth required to play back the stream.

BURSTING

Burst-mode delivery or "Bursting" is a method of multimedia delivery that delivers data "faster than real time." It is similar to streaming in that it starts playing the media almost instantaneously upon request without waiting to download the entire file. However, bursting can use a larger buffer than streaming, and can therefore hold more than just a few seconds of data. The size of this buffer does not impact the delay between the client request and the media playback.

Rather than a consistent stream of data, bursting uses the bandwidth between client and server more efficiently than streaming by sending as much of the data as it can in a series of "bursts" to fill the player's buffer. In the 100Kbps stream example, if the amount of bandwidth between client and server is 512Kbps, bursting will deliver the stream in bursts at bit rates up to 512Kbps, while still allowing other types of traffic to and from the client. The player will still playback the media at 100Kbps, but the player's buffer will quickly fill with the extra data.

Bursting technology for streaming media delivery is patented by Burst.com in their Burstware product line.

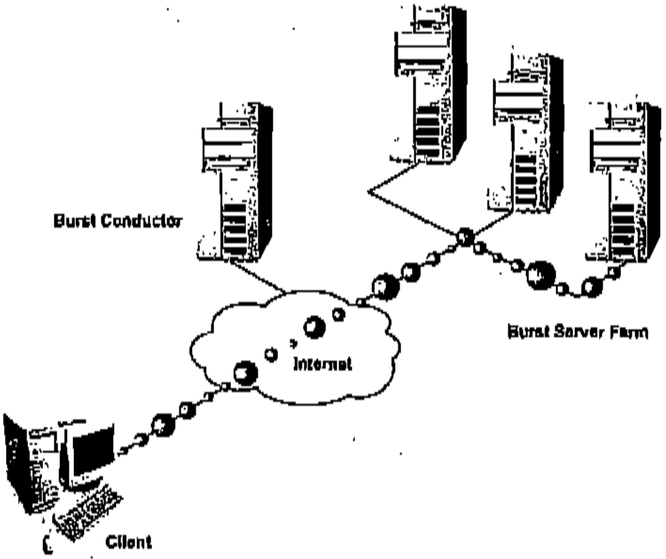

Figure 2: Sample Burstware architecture

Figure 2 illustrates a Burstware-enabled streaming infrastructure. A server farm of Burstware servers and a Burstware Conductor sit in some hosted position on the Internet. Client requests are sent to the Conductor, which automatically redirects the client to the least loaded Burstware server to feed the stream. The Burstware server sends data in bursts greater than the playback rate of the file to fill the client's buffer rather than sending a consistent stream.

EDGE CACHING

Edge caching is a technique that overcomes the major problems inherent in streaming: insufficient bandwidth and network congestion. Whereas with streaming, servers are usually hosted in a centralized way (i.e., single geographic location or single network access point), edge caching uses a distributed model to decentralize the servers and bring them "closer" to the end user. This may involve placing servers in multiple geographic locations and at multiple ISPs that have a large number of clients (known as "edge positions"). Media content is cached on these edge servers and served to users rather than having them connect to a central position for delivery. If content is requested but not found in a server's cache, the server connects to a source server and requests the file. Once the file is retrieved, it is stored in the server's cache until a specified timeout is reached where the file is no longer requested.

One of the goals of edge caching is to reduce the number of "hops" it takes for the stream to reach the user. Figure 3 illustrates a simplified topology of the Internet showing the path that traffic on the Internet takes to go from server to client. Packets from Client B for example must pass through multiple ISPs and cross the Internet backbone before they reach the media server. During each hop, there is an increase in latency (delay) and the increased potential for the data to become corrupted along the way (due to packet loss, buffer overflow, fragmentation or out-of-sequence packets). If, at any point, information does not reach the player in time for the user to view the data and the buffer time runs out, the user will experience packet loss, and therefore a reduction in audio and video quality. Edge caching places servers at the ISP's point of presence (POPs), data centers and upper-tier providers to reduce the number of hops and avoid having to cross congested communication links such as the Internet backbone. Private links such as satellite communications between the host and providers may also be employed by caching solutions to provide a shortcut for data transmission.

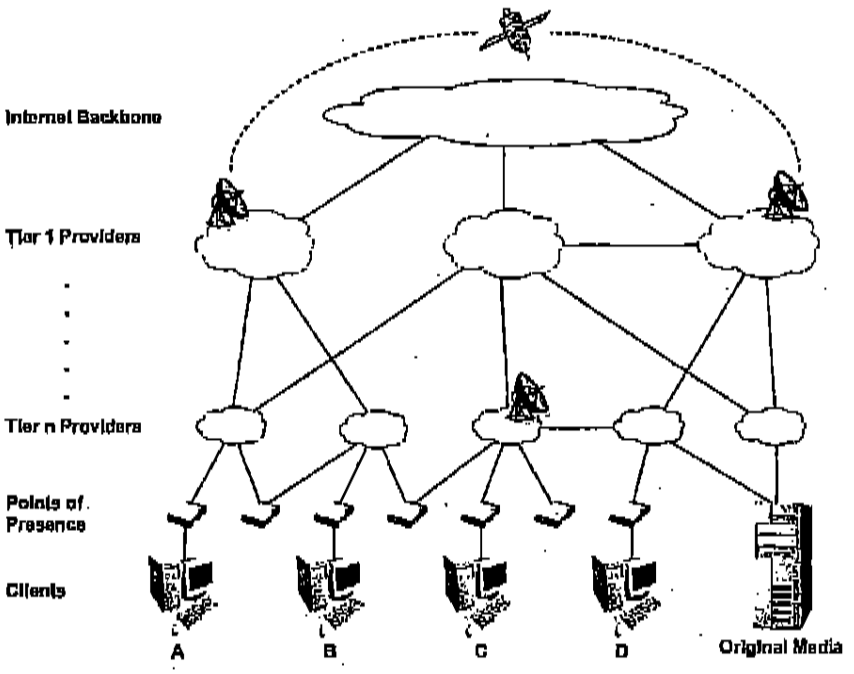

Figure 3: Simplified topology of the Internet

Edge caching can be offered to a content provider either as a service or as a product. Services such as Akamai provide the caching servers and host the content providers' content at multiple remote locations. Products such as Inktomi's Traffic Server can be purchased and hosted by the Internet content provider (ICP).

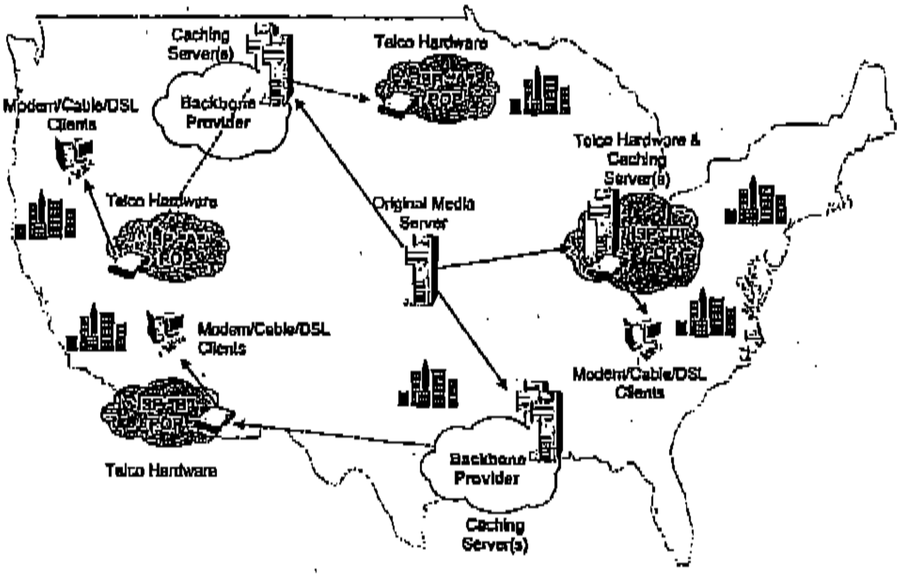

Figure 4: Sample edge caching architecture

Figure 4 illustrates a sample edge caching solution with cache servers placed at multiple Level 1 backbone providers (light gray clouds) and strategic geographic locations (ISP "C" on the east coast). Users dial into their local POP (dark gray clouds) and request streams from a local cache server or one hosted at the backbone provider. This prevents streams from being carried across the Internet backbone. When a stream is not found in a cache, it is re-requested from the source server.

EDGE SERVING

Edge serving is very similar to edge caching with regard to placement of servers; the difference being the way content is managed on the edge servers. With edge caching content is cached and stored until a certain timeout period. If a request comes in for a media file that is not cached, the cache server requests the file from a source server and then stores it in its cache. With edge serving, content is pushed out to the edge servers before it is requested. Each server stores a complete or partial copy of the content based on the popularity of the media. When a request comes in for a stream, the edge server does not need to retrieve the media from an source server. Instead, it tries to serve the file from its local copy and if it is not found, it redirects the user to a server that does have the file.

Some edge delivery strategies combine both edge caching and edge serving techniques. Here, media that is known to be in high demand will be pushed out to the edge servers using an edge serving technique, while other files in less demand are retrieved similar to edge caching.

Edge serving is offered by Kasenna.

V. PERFORMANCE TESTING

A test environment was created at Approach Inc. to determine the best possible technical strategy for addressing the growing complexities and challenges of streaming media. The test lab simulated real-world conditions on the Internet in order to test and compare the performance of conventional streaming using Windows Media and Burstware. Windows Media was selected because it represents the best case for conventional streaming and has a lower cost of implementation than Real or QuickTime. (Go to http://www.microsoft.com/windows/windowsmedia/en/compare/wmcostcompare.asp for a comparison of Real and Windows Media.) Edge caching and edge serving were also compared based on extrapolations from the results of these lab tests.

TEST LAB DESIGN

The test lab consisted of two identically configured servers and four identical clients. Burstware 2.1 Server was installed on Microsoft Windows 2000 Server on one server, and Burstware 2.1 Conductor was installed on the second server for the Burstware tests. Microsoft Windows Media Services 4.1 running on a single Windows 2000 Server was selected for all of the streaming tests because both Burstware 2.1 and Windows Media share support for the ASF file format and use the same Windows Media Player client for playback.

To simulate the Internet or an enterprise wide area network (WAN) in the case of the intranet scenarios, Shunra Software's The Cloud version 2.1 was selected, which is an industry-accepted WAN simulation tool. The WAN simulator acted as a bridge between the servers and clients and affected all traffic that passed between them based on preset values.

The following diagram illustrates the layout of the test lab:

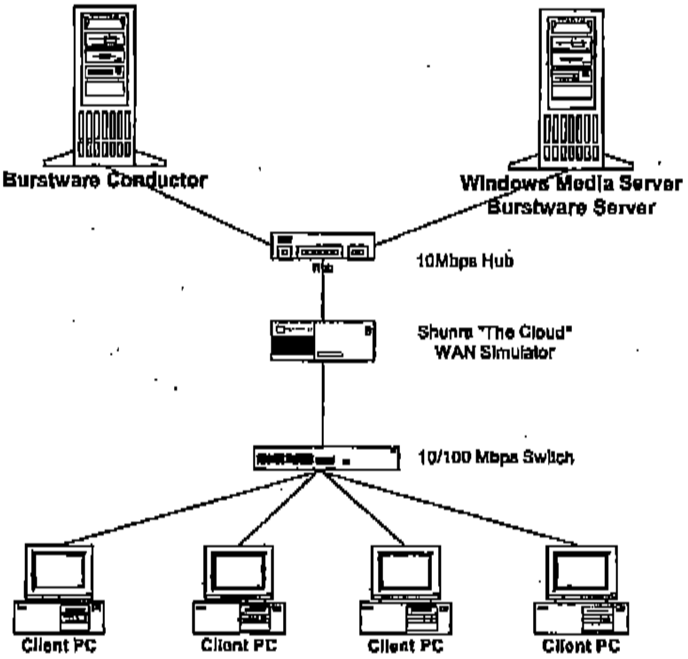

Figure 5: Lab layout

	PC	RAM	Disk	Network Card	Software
Streaming/Burstware server	Pentium III-667 MHz	512 MB RAM	18GB RAID 0	10/100 Mb NIC	Windows 2000 Server, Windows Media Services 4.1, Burstware Server 2.1
Burstware Conductor	Pentium III-667 MHz	512 MB RAM	9GB RAID 0	10/100 Mb NIC	Windows 2000 Server, Windows Media Services 4.1, Burstware Conductor 2.1
Client PCs	Pentium II-350 MHz	128 MB RAM		10/100 Mb NIC	Windows 2000 Professional, Windows Media Player 6.4, Burstware Bridge 2.1 for Windows Media Player
WAN Simulator	Pentium Pro 200 MHz	144 MB RAM		2x 10/100 Mb NICs	Microsoft Windows NT 4.0 w/ service pack 6a, Shunra Software The Cloud version 2.1

Table 1: Lab components

Test Categories

Two categories were used as the basis for the tests:

SCALABILITY AND CAPACITY

The first test was designed to measure how many successful media streams each solution could serve within a given amount of time. This measurement indicates the scalability of each product and the how efficiently it used available resources. The tests compared Burstware to Windows Media Streaming in a centralized hosting model, where all servers are located in a single site.

Burstware was not compared to streaming with edge caching because edge caching is infinitely scalable since servers are distributed among multiple locations. There are no bandwidth constraint issues at any single point in the solution. Furthermore, it would be nearly impossible to simulate a distributed caching model that behaves in the lab the way it would on the Internet. Therefore, Burstware was compared to streaming with edge caching in a different set of tests.

QUALITY

This quality test measured the effectiveness of both edge caching and bursting by measuring the quality of the end user experience. Both edge caching and bursting improve end-user quality, but do so by different approaches. This test compared the methods that both edge caching and bursting employ to deliver a good quality stream to the user regardless of network affects.

VI. TEST RESULTS

SCALABILITY AND CAPACITY TEST

OVERVIEW

Traffic on the Internet is rarely predictable. It is subject to various conditions that affect performance and reliability, which can be defined by parameters such as latency (delay), jitter (varying delay), packet loss, packet errors and fragmentation. Assumptions were made in order to simulate similar conditions in the lab. Whenever possible, the assumptions were validated based on real-world data.

The WAN simulator provided network effects consistent with what is found on the Internet through the introduction of random packet loss and latency. Thresholds for packet loss and latency were based on publicly available measurements taken from major backbone providers in the United States such as UUNet, AT&T and Cable & Wireless. Based on these statistics, the network latency was set to 70 ms ± 10 ms. Therefore, the latency could be expected to vary between 60 and 80 ms (jitter). Packet loss was set to 1% (random distribution) loss. Additionally, the WAN simulator was used to limit the link speed (bandwidth) between the servers and the Internet cloud to imitate leased bandwidth (i.e., T1, fractional T1, multiple T's, etc.) and Ethernet LAN speeds. The bandwidth was adjusted for each test scenario accordingly.

Clients in the test sessions were launched in large numbers from four client PCs in the lab at a rate that varies over time. As depicted in figure 6, the client arrival rate oscillates between two and six clients per minute over a 200 second interval.

This set of tests was designed to reproduce the time-varying nature of the load experienced by most websites where traffic peaks and then drops off at different times of the day. Tests were performed with the Microsoft Windows Media Player and were run for a period of 1 hour with 5-minute stream lengths.

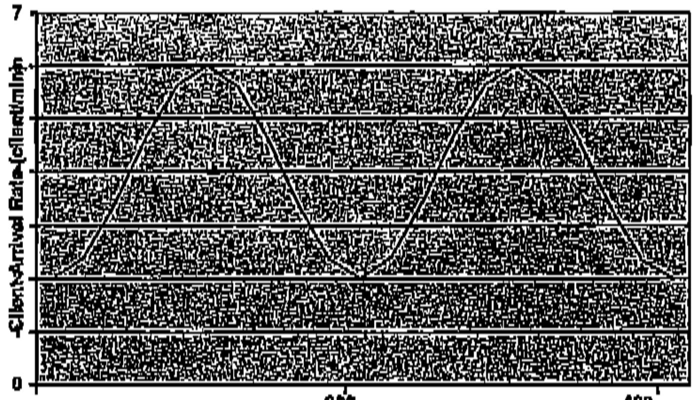

Figure 6: Variation of client arrival rate over time

RESULTS AND OBSERVATIONS

Results were gathered from the log files produced from the Windows Media and Burstware servers. Each test was repeated 3 times and the averages of the results are shown in the following table.

	Distance Learning	Entertainment	Corporate Intranet
Windows Media 4.1	274	161	307
Burstware 2.1	343	202	352
% difference	+25%	+25%	+15%

Table 2: Number of clients served over a period of 1 hour.

These results show that Burstware was able to serve approximately 15%-25% more users under then Windows Media under the same test conditions.

Quality Test

Overview

Quality degradation can be measured in two ways: the bit rate at which the file is played back, and the number of times the stream pauses to buffer. If the bit rate at which the file is played back is equal to the rate at which the original media was captured, then it can be assumed that the player received and played back 100% of the data. However, if the playback rate is less than the encode rate, then it can be assumed that frames were lost or some pixelation in video or breaks in audio may have occurred during playback. In the worst case, the player might even pause to buffer and catch up during periods of high loss, which completely pauses video and audio playback.

Again, assumptions were made about each product in the lab. Since caching cannot be easily simulated in a lab, the assumption was made that a caching server acts the same as having another streaming server at the down-level position (i.e., same streaming protocols in use, no CPU, RAM or disk bottlenecks). The key end-user benefit of caching depends on where the server is placed and not actually how it functions. Microsoft Windows Media Services was used to simulate the behavior of an edge cache server with a 100% cache hit ratio.

Congestion events, characterized by extremely high packet loss (10%), network latency (500ms) and un-reachability, lasting from one to five seconds, were injected at random. The simulator (see Figure 5) was configured for an aggregate bandwidth of 10Mbps. 12 clients were added for streaming and bursting alike.

Results and Observations

The times each player buffered and the average playback bit rate were determined by observing the playback and using the log from both Windows Media and Burstware servers. The following table shows the average bit rate at which the player played back the 300 Kbps stream and the number of times the stream paused during audio/video playback. The results are an average of 3 trials.

	Average bit rate
Burstware 2.1	279.4 Kbps
Windows Media 4.1	99.3 Kbps

Table 3a: Average playback rate

	Average # of pauses
Burstware 2.1	0
Windows Media 4.1	4.17

Table 3b: Number of pauses in video under network congestion

ANALYSIS OF TEST RESULTS

Given the same bandwidth restrictions, network conditions, and client "hit" rate, Burstware was able to service more client requests in a 30 minute period than Windows Media. This can be attributed to the fact that bursting sends the media to the client faster than the playback rate. In some cases, the Burstware client buffered the entire 5-minute clip into memory in just 3 ½ to 4 minutes. With the entire clip buffered, the client disconnected from the server, thereby giving the Burstware server an extra 1 to 1 ½ minutes to serve other clients.

More Burstware clients were able to playback the stream concurrently for the same reason; Burstware sends the media to the client faster than the playback rate. Since client #1 was able to receive the entire clip in 4 minutes, client #2 started playing while client #1 was still playing from its local buffer. Therefore, the clients play concurrently without using more bandwidth than a single client would.

Streaming, on the other hand, sends a very consistent stream of data that lasts as long as the client is watching the media clip. Under the same bandwidth constraints, client #2 had to wait for client #1 to finish playing the stream until it was able to start playback.

Given the same network conditions, Burstware was able to deliver a higher quality end-user experience than Windows Media. At higher bit rates, users experience a smoother frame rate, better quality video, and better quality audio. Because Burstware clients achieved a higher playback bit rate than Windows Media, the quality of audio and video was better.

The improved quality by Burstware can be attributed to the client-side buffer used by the Burstware player. The buffer is able to feed data to the player even when temporary network conditions prohibit data from being transmitted to the client. Without this buffer, Windows Media was forced to drop packets and in the extreme cases pause to re-buffer until the network congestion cleared. This increased packet loss also forced Windows Media to throttle down the quality of the stream to a lower bit rate, which is streaming technology's default behavior when faced with network congestion.

This test shows that Burstware is more resilient to the unpredictability of network conditions that can be found on internal networks or large wide area networks such as the Internet. For example, a period of network congestion might be caused by a communications link failure, a sudden increase in network traffic or other unforeseen event. Because Burstware is less affected by network congestion, it does not need to sit as far on the "edge" of the network as caching tries to accomplish. A few strategically placed Burstware servers may be able to deliver the same quality to the end-user as numerous edge cache servers.

VII. BURSTWARE TECHNICAL BENEFITS

CENTRALIZED STREAMING VS. CENTRALIZED BURSTING

The lab results show that hosting media on a Burstware platform has numerous advantages for both the content provider and end-user.

MORE SCALABLE

Tests showed that Burstware was able to serve more clients than conventional streaming due to faster, more efficient processing. More clients were able to play the stream concurrently while maintaining a consistent level of quality and without requiring additional bandwidth. In addition, since the media file is being sent to the client faster than the player can play it, Burstware finishes transmitting the stream earlier, thereby freeing the server of that client's load. The server can therefore handle new requests more efficiently.

IMPROVED USER QUALITY OF SERVICE

Burstware improves the quality of the users' ~~experience, even~~ in adverse conditions. When the server-client bandwidth is constrained, rather than thinning and reducing the quality of the media, the player plays the data stored in the buffer to maintain a high-quality and error-free stream. The user does not even know that the network is congested. This provides users with a better experience during periods of network congestion.

BUILT-IN FAULT TOLERANCE

A Burstware-enabled multimedia delivery network includes built-in fault tolerance. The Burstware Conductor continuously monitors all Burstware Servers in its control. Should a Burstware Server become unavailable, the Conductor will redirect user-requests to other Burstware Servers in its control automatically and transparently to the user. Burstware Conductors have the added benefit of failover even during media playback. If an end-user loses contact with a Burstware Server, either due to system or network failure, the Conductor automatically transfers control to the next available Server to continue media delivery. Failover is performed transparently so the end-user, who is protected by the Burstware player's buffer, may never know an error occurred.

BUILT-IN LOAD BALANCING

Burstware also includes built-in load balancing services into its product. User requests are automatically sent to servers with the least load to optimally use network and infrastructure resources. Caching and streaming do not have native load-balancing services. In order to achieve the same effect, additional network load balancing hardware (such as Cisco's Load Director or F5 Networks' BIG-IP) or software (such as Microsoft Windows Load Balancing Service) must be purchased. This not only introduces additional cost, but also additional points of failure.

FORMAT INDEPENDENCE

Another advantage to Burstware is format independence. A Burstware server can serve many different types of media formats such as MPEG1, MPEG2, MP3, Apple QuickTime, Microsoft ASF, AVI, WAV, with support expected for many more formats in the future. Streaming solutions are generally format specific, meaning that one would need to implement multiple services to support different file formats, which introduces additional infrastructure, software licensing and support costs. Converting multiple media types to a single format also incurs additional cost and production time.

STREAMING EDGE CACHING VS. EDGE SERVING WITH BURSTWARE

The lab also results show that Burstware in an edge serving environment has a number of advantages over streaming with edge caching.

RESOLUTION OF CLIENT BANDWIDTH CONSTRAINTS

By placing servers closer to the user and streaming content from these servers rather than a centralized hosting server, edge caching attempts to reduce bandwidth costs and minimizes the impact of congestion at the hosting position. However, if network problems occur closer to the user, the user may still receive a poor quality experience. For example, if a dial-up user attempts to download a file from a website while watching a stream from an edge-cache server, caching will provide little benefit, since bandwidth, in this case, is constrained by the speed of the user's connection and not by traffic on the Internet. Burstware addresses this by monitoring network, server and client conditions and adapting the use of resources for each client. If congestion occurs at the client, the player continues to receive data from its buffer until the congestion event ends, ensuring a higher quality experience.

RESOLUTION OF SERVER BANDWIDTH CONSTRAINTS

Another problem with edge caching's claim of reducing end-to-end bandwidth requirements is the actual performance of the caching algorithm used by caching vendors. According to measurements from IRCache.net's annual Web Cache Bake Off[1], caching achieves an average hit ratio of less than 50%. If streams are being requested at random, more than half of the requests incur a trip back to the source server to replicate the stream. Multiply this by the number of cache servers deployed and that translates to a lot of traffic back to the source server. The streams coming from origin streaming servers located deep inside the internet are likely to encounter network interruptions on their path to the end-user. Burstware alleviates this problem by load-balancing the content among all servers. If a user requests a stream and the Burstware Conductor determines that the first Burstware Server in its list doesn't have the content stored locally, the Conductor continues through its list of available servers until it finds one with the media available. The effective availability of any stream is 100% because a single user is not tied to a single server. This way bandwidth to a central hosting position is conserved.

Low cache hit ratios introduces another problem with caching: small players who do not have the volume of larger content providers end up losing out because their content gets aged more frequently than content that is requested more often. Therefore, cache hits for smaller Internet content providers (ICPs) that compete with larger ones may be significantly lower than expected. Because Burstware requires fewer servers to reach the same audience, a full copy of all data can be kept on these few servers, thereby avoiding some of the problems commonly found with edge cache solutions.

LESS EDGE SERVERS

In an edge caching solution, the service provider places caching devices in multiple strategic edge locations. For example, if a large number of dial-up and broadband visitors are expected from ISP ABC, a caching server would be placed at multiple locations either at the ISP's data center or at the point of presence that is close to the users. Because every router hop introduces some measure of latency and the potential for packet loss, caching servers are generally placed within two or three hops from the end-user. In figure 3 above, cache servers would sit at the point of presence or the lower tier n positions. Since users could be connecting to the Internet via any number of ISPs, placing caching servers at hundreds or thousands of locations is costly.

[1] http://cacheoff.ircache.net/

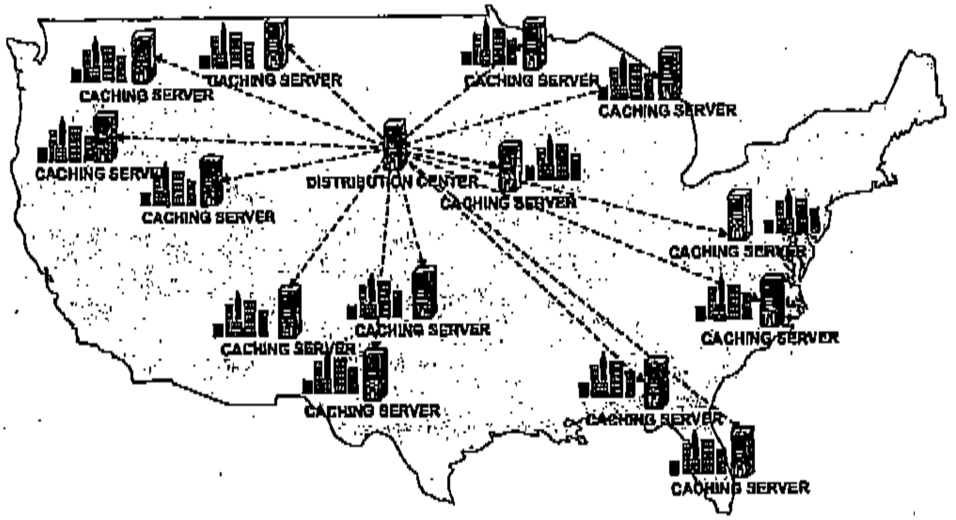

Figure 7: Sample edge caching server placement

Burstware overcomes this problem by allowing servers to be placed in far fewer edge locations but at the same time maintain a high-quality user experience. Burstware server farms could be placed at strategic locations along the Internet backbone. For example, referring to figure 3, a Burstware server at a tier 1 backbone provider's data center on the East Coast, a server on the West Coast and a server in the Midwest could give the same performance as having multiple servers in multiple locations. In this case, a single Burstware server reaches a much broader audience. Although content delivered from Burstware servers in this case require more hops to reach the client, the tests show that the Burstware buffer ensures that the stream quality is always maintained even during periods of congestion. Fewer servers in fewer locations translates to a significant cost savings for the customer.

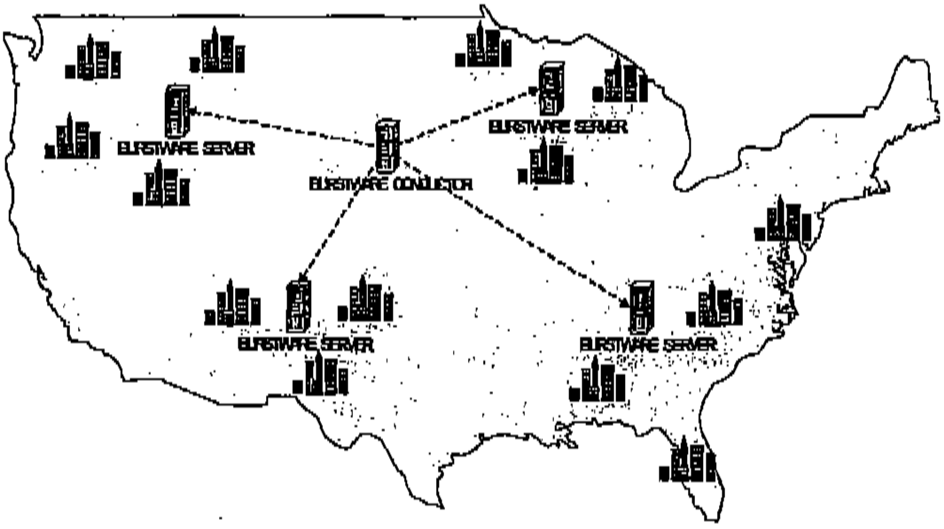

Figure 6: **Sample Burstware server placement**

By reducing the number of servers, one also reduces the cost of distributing content across cache servers. Edge caching servers often replicate content on a demand basis: when a user requests a stream that is not found in the cache, the cache server contacts the original source server and pulls down the stream either via the network, or over a private satellite link. The file is then served to the user and cached locally for a preset period of time. The problem with this mode of distribution is that often streams are carried over the same wide area links that carry Internet traffic. This introduces the same latency and network errors between the source server and the edge cache server that edge caching attempts to solve.

IMPLICATIONS FOR MARKET SEGMENTS

How do these advantages for Burstware benefit the customers in the market segments described above? Business in all market segments described above would be able to offer a better quality streaming experience for the end-user due to Burstware's ability to deliver content to a large client-side buffer which is viewed by the user during network glitches and outages. Customers in the entertainment market segment, whose sites are characterized by extreme traffic peaks and unpredictable volumes would benefit from Burstware's ability to manage bandwidth effectively and to deliver media streams faster than other methods, freeing up bandwidth to serve more clients. The distance-learning market segment would find the quality available through Burstware as an added benefit for the students. Internal corporate networks concerned with the impact that streaming media might have on the rest of their networks would benefit from the enhanced ability to manage bandwidth and delivery speed.

VIII. COST ANALYSIS

In this study, total cost of ownership (TCO) for implementing Burstware, conventional streaming with Windows Media, edge caching and edge serving were calculated. The TCO is defined as the total amount spent on technology over a specific period of time. The TCO model is intended to help enterprises understand the total costs associated with owning, using, and maintaining a specific technology and make decisions regarding selection of technology products. TCO model factors in both direct costs (estimated and planned for) and indirect costs over a period of time.

The calculations considered the initial infrastructure costs for the first year and the additional costs for the subsequent two years. This study examine the following aspects of cost of ownership:

- Hardware costs - Server system, Burstware Conductor (for the Burstware option), network load balancing hardware.
- Software costs - Server operating system, server software, Burstware Conductor software, and client software.
- Bandwidth costs.
- Content conversion costs
- Vendor Support costs.

The study determined the costs for implementing each technology strategy at the same level of functionality and quality. This required upgrading the Windows Media base infrastructure in order to ensure consistency as follows:

- Load balancing is built into the Burstware software. To achieve load balancing with Windows Media, load balancing hardware was required. The F5 Network Load Balancing hardware was included at an additional cost of $25,000 to the Windows Media option.
- Over a period of time, Burstware was able to serve more clients than conventional streaming. For conventional streaming to be able to serve the same number of clients over time as Burstware, additional bandwidth was required.
- In order to achieve the same level of quality as Burstware, conventional streaming required additional bandwidth.
- Windows Media required additional encoding software to stream MPEG1, MPEG2, MP3, Apple QuickTime and AVI, files while Burstware does this automatically.

Three scenarios, described below, were used to identify the criteria and assumptions upon which to base the costs. Testing was done on the lab using the variables in the scenarios to verify the performance as well as cost comparisons.

A. Entertainment Internet Service Provider

Setting

An entertainment Internet service provider (ISP) provides hosting and streaming media services for radio and TV re-broadcasting and video producers. The company estimates that they currently transfer up to 11,000GB per month.

Objective

The company's key concern is how to support a significant increase in streaming capacity while ensuring a positive streaming experience. They anticipate transferring an additional 5,000GB per month, a 50% increase over their regular traffic. This will be a sudden and dramatic increase to the company's current business.

CHALLENGE AND CONSTRAINTS

They must support an average of 3.5 million users per month, 250 concurrent users with peak volumes of up to 350 concurrent users. Users would be watching media such as sports highlights, newscasts, music videos, or movie clips at medium quality (128 kbps encode rate), and users would have broadband connections to the Internet such as cable, DSL or T1 with an effective throughput of 256 Kbps. They currently purchase 20Mps bandwidth per month and must be able to stream content in multiple formats such as MPEG1, MPEG2 , MP3, QuickTime, AVI and Windows Media. Clients have over 300 minutes of existing non-ASF content to be streamed. The following table summarizes the variables used in the entertainment ISP test.

Variables	
Total monthly data transfer	16,000GB
Average concurrent users	250
Peak concurrent users	350
Number of users per month	3.5 million
Bandwidth purchased per month	50Mbps
Stream Capture Rate	128 Kbps
Stream Length	5 minutes
Client Bandwidth	256 Kbps
Rate (interval between introduction of a new client)	10 seconds
Server Bandwidth	3 Mbps
Duration of test	30 minutes

Table 4: Entertainment scenario variables

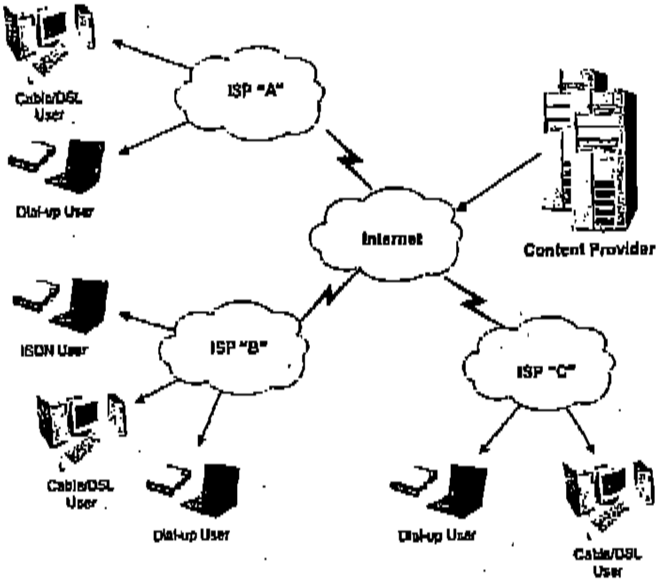

Figure 9: Entertainment scenario architecture

Costs

Centralized streaming

Year one costs: Burstware technology	$623,650
Year one costs: Windows Media	$1,106,450
Savings due to Burstware	$428,800

Table 5: Entertainment scenario cost summary

Burstware was 43% less costly than Windows media primarily because:

- Burstware required 45% less bandwidth costs. Burstware could handle higher volumes with less bandwidth than conventional streaming. Based on test results, 40 Mbps bandwidth was estimated for Burstware. To achieve the same level of quality and volume as Burstware, an additional 25% or 50 Mbps was estimated for conventional streaming. In this scenario, the resulting cost saving was $40,000 per month. (Note, the actual cost savings resulting from bandwidth purchases will vary based on the provider's pricing schemes.)
- Windows Media required $21,500 more spent on hardware due to the load balancing hardware. Refer to Appendix 3 for cost details.

Entertainment ISP TCO	Burstware	Windows Media
Total hardware	$9,500	$31,5,000
Total software costs	$23,000	$1,000
Encoding costs	$0	$4,500
Annual cost of Bandwidth and setup	$588,000	$1,068,000
Total support	$3,150	$3,900
Total cost (year one)	**$623,650**	**$1,106,450**
Cumulative Savings with Burstware	$482,800	$1,071,900
Additional Cost for Year Two (bandwidth and Support)	$591,150	$543,900
Cumulative cost (year two)	**$1,214,800**	**$2,176,400**
Cumulative Savings with Burstware	$961,600	
Additional Cost for Year Three	$591,150	$1,071,900
Cumulative cost (year three)	**$1,805,950**	**$3,246,350**
Cumulative Savings with Burstware	$1,440,400	

Table 6: Entertainment Scenario Burstware and Windows Media TCO

Distributed Streaming

Year one costs: Edge serving with Burstware	**$8,140,300**
Year one costs: Edge caching	**$10,626,450**
Savings due to Burstware	**$2,486,150**

Table 7: Entertainment scenario distributed streaming cost summary

The analysis shows that edge serving with Burstware costs 21% less than edge caching. These savings are primarily attributed to using fewer servers with Burstware. It was estimated, based on the test results, that this scenario would need approximately 24 servers for edge serving with Burstware required 24 servers while the edge caching required 30. This resulted in a savings in $1.8 million in annual bandwidth costs, $568,000 in software costs and $80,500 in hardware costs.

Entertainment ISP TCO	Edge Serving with Burstware	Edge Caching
Total hardware	$339,500	$420,000
Total software costs	$272,000	$840,000
Encoding costs	$0	$4,500
Annual cost of Bandwidth and setup	$7,488,000	$9,360,000
Total support	$40,800	$1,950
Total cost (year one)	$8,140,300	$10,262,450
Cumulative Savings with Burstware	$2,486,150	
Additional Cost for Year Two (bandwidth and Support)	$7,528,800	$9,361,950
Cumulative cost (year two)	$15,669,100	$19,988,400
Cumulative Savings with Burstware	$4,319,300	
Additional Cost for Year Three	$7,528,800	$9,361,950
Cumulative cost (year three)	$23,197,900	$29,250,350
Cumulative Savings with Burstware	$6,152,450	

Table 8: Entertainment scenario edge caching and edge serving TCO

Refer to Appendix 3 for cost details.

B. Distance Learning

Setting

A provider of e-learning solutions for universities and corporations is planning to offer streaming media for the first time. The company works with clients to create and host the virtual classroom: an Internet-based environment with structured learning programs.

Objective

The company plans to initiate streaming media with a few of the universities who have committed to enhancing their websites with streaming media.

Challenge and Constraints

They will initially transfer 800GB of data each month. In addition to new content, clients have over 500 minutes of existing MPEG1, MPEG2 and MP3 that they want to be streamed. They estimate having 100,000 streaming media users per month and plan to support peak volumes of 350 concurrent users.

Distance-learning users would be connecting to servers using a relatively low bandwidth connection such as dial-up or ISDN modems. Therefore, the Burstware Media Player Bridge was set to 53 Kbps to simulate clients connecting via 56K modem. For Windows Media, the client bandwidth settings do not need to be adjusted because the stream will never play at a rate greater than the capture rate, regardless of the amount of bandwidth available to the client. Furthermore, distance-learning media itself is traditionally not bandwidth-intensive – usually one person lecturing at a time (audio only) with accompanying slides and perhaps some screen shots or low frame rate video. Therefore, a sample media file captured at 37 Kbps was used.

Variables	Distance Learning
Total monthly data transfer	800GB
Average concurrent users	250
Peak concurrent users	350
Number of users per month	100,000
Bandwidth purchased per month	2 Mbps
Stream capture rate	37 Kbps
Stream length	30 minutes
Client bandwidth	53 Kbps
Rate (interval between introduction of a new client)	10 seconds
Server bandwidth	1 Mbps
Duration of test	30 minutes

Table 9: Distance-learning scenario variables

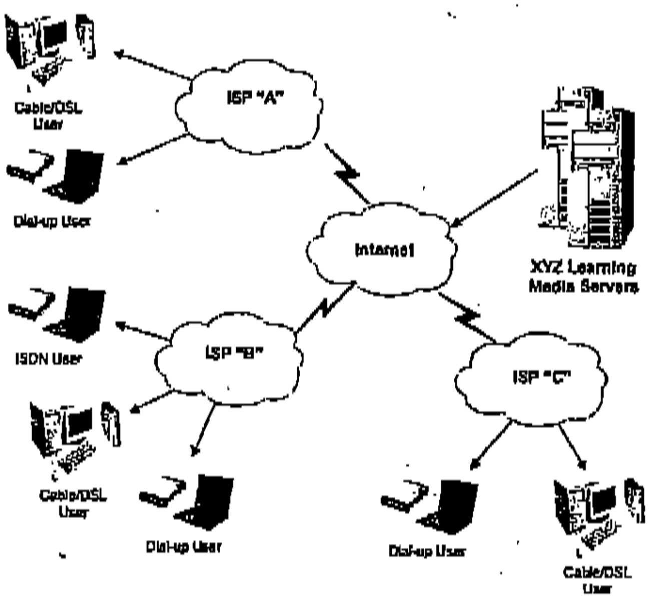

Figure 10: Distance-learning architecture

COSTS

Centralized streaming

Year one costs: Burstware technology	$149,500
Year one costs: Windows Media	$179,450
Savings due to Burstware	$29,950

Table 10: Distance-learning scenario centralized streaming cost summary

For this scenario, illustrating a much smaller application of streaming media, the cost analysis showed Burstware technology being 16.7% less than Windows Media in the first year. Windows media incurred cost for:

- Re-encoding content ($7,500)
- Load balancing hardware ($25,000).

Based on the pricing scheme used in this paper, costs for bandwidth were the same for Burstware and Windows Media. Refer to Appendix 3 for cost details.

Distance-learning TCO	Burstware	Windows Media
Total Hardware	$9,500	$31,000
Total software costs	$2,000	$1,000

Distance-learning TCO	Burstware	Windows Media
Encoding costs	$0	$7,500
Total cost of bandwidth	$11,500	$11,500
Support total (year one)	$0	$1,950
Total cost (year one)	**$149,500**	**$179,450**
Cumulative Savings with Burstware	$29,950	
Additional Cost for Year Two(bandwidth and Support)	$138,000	$139,950
Cumulative cost (year two)	**$278,500**	**$319,400**
Cumulative Savings with Burstware	$31,900	$13,450
Additional Cost for Year Three(bandwidth and Support)	$138,000	$139,950
Cumulative cost (year three)	**$425,500**	**$459,350**
Cumulative Savings with Burstware	$33,850	

Table 11: Distance-learning scenario Burstware and Windows Media TCO

Distributed Streaming

Year one costs: Edge serving with Burstware	$3,964,300
Year one costs: Edge caching	$5,406,540
Savings due to Burstware	$1,442,150

Table 12: Distance-learning distributed streaming cost summary

Edge serving with Burstware was shown to cost 26% less edge caching. Using 24 servers for edge serving with Burstware and 30 servers with edge caching resulted in savings of $828,000 in bandwidth costs, and $568,000 in software costs and $80,500 in hardware costs.

Distance-learning TCO	Edge Serving with Burstware	Edge Caching
Total Hardware	$339,500	$420,000
Total software costs	$272,000	$840,000
Encoding costs	$0	$4,500
Total cost of Bandwidth and setup	$624,000	$780,000
Support Total (Year One)	$40,800	$1,950

Distance-learning TCO	Edge Serving with Burstware	Edge Caching
Total Cost (Year One)	**$3,964,300**	**$5,406,450**
Cumulative Savings with Burstware	$1,442,150	
Additional Cost for Year Two	$699,600	$781,950
Cumulative Cost (Year Two)	**$7,317,100**	**$9,548,400**
Cumulative Savings with Burstware	$2,231,300	
Additional Cost for Year Three	$699,600	$781,950
Cumulative Cost (Year Three)	**$10,669,900**	**$13,690,350**
Cumulative Savings with Burstware	$3,020,450	

Table 13: Distance-learning scenario edge caching and edge serving TCO

C. CORPORATE COMMUNICATIONS

SETTING

A worldwide consumer products company operates from 11 locations worldwide and has an intranet that supports the company's 40,000 international employees.

OBJECTIVE

The company is considering using streaming media to enhance corporate and product communications and sales training. Company-wide announcements and the CEO address will be available to everyone on the company intranet, not just those who work at headquarters. The company has 2,000 US-based sales employees located primarily at four regional sales offices and 20 district sales offices. Sales employees attend up to seven days of training per year, typically four days of training at corporate headquarters and three days of training locally where the trainer visits their district. Corporate videos, product demonstration videos, audiocassettes and CDs containing multimedia presentations are mailed out each quarter to every district sales office and every field sales employee.

CHALLENGE AND CONSTRAINTS

Users at the company connect to a fairly high-speed enterprise WAN and media would be fairly broadband (300 Kbps) with each user having an effective shared throughput of about 640 Kbps per user. The company-wide standard for streaming is Windows Media and has up to 20 MPEG1, MPEG2 and MP3 files, averaging 20 minutes in length that will also be made available to users.

Variables	Corporate Intranet
Average concurrent users	250
Peak concurrent users	350
Number of users per month	75,000
Bandwidth purchased per month	15 Mbps
Stream Capture Rate	300 Kbps
Stream Length	30 minutes
Rate (interval between introduction of a new client)	10 seconds
Server Bandwidth	10 Mbps
Client Bandwidth	640 Kbps
Duration of test	10 minutes

Table 14: Corporate communications scenario variables

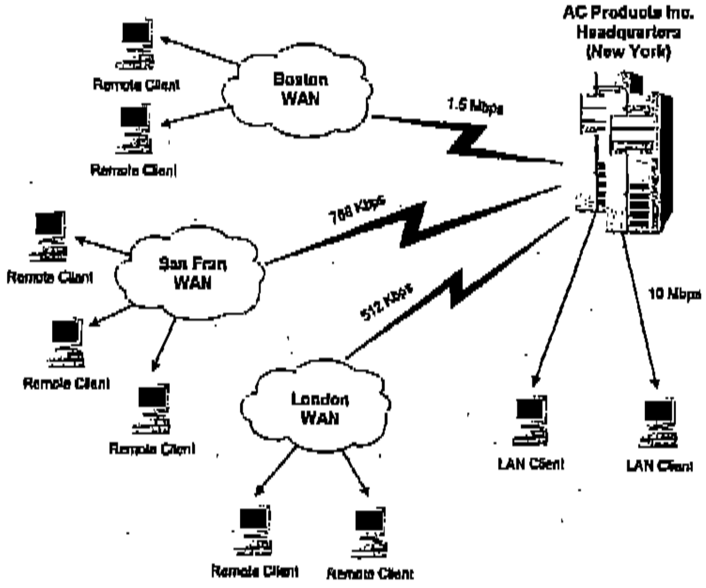

Figure 11: Corporate communications scenario architecture

COSTS

Centralized streaming

Year one costs: Burstware technology	$389,460
Year one costs: Windows Media	$460,000
Three year savings with Burstware	$70,540

Table 15: Corporate communications centralized streaming cost summary

In this corporate communications scenario, Burstware proved to cost 15.3% less than Windows Media for the first year. The differences in costs were due to:

- The lower bandwidth cost. The monthly bandwidth cost was $6,500 less than the Windows Media option.
- Lower hardware costs. Windows Media incurred an additional $21,500 due to load balancing hardware.
- Windows Media option incurred costs for re-encoding content ($6,000).
- The Windows Media option utilized Microsoft's Enterprise Premiere Support which costs $25,000.

Corporate Communications TCO	Burstware	Windows Media
Total Hardware	$9,500	$31,000
Total software costs	$51,270	$2,000
Encoding costs	$0	$6,000
Total cost of bandwidth	$312,000	$390,000
Support total (year one)	$7,690	$25,000
Total cost (year one)	$389,460	$460,000
Cumulative Savings with Burstware	$70,540	
Additional Cost for Year Two (bandwidth and Support)	$319,690	$415,000
Cumulative cost (year two)	$709,150	$875,000
Cumulative Savings with Burstware	$165,850	
Additional Cost for Year Three(bandwidth and Support)	$138,000	$139,950
Cumulative cost (year three)	$1,028,841	$1,290,000
Cumulative Savings with Burstware	$261,159	

Table 16: Corporate communications Burstware and Windows Media TCO

An edge caching and edge serving cost analysis was not computed for the corporate communications scenario. These technologies are more applicable to external networks than they are for internal intranets.

RETURN ON INVESTMENT

Return on investment (ROI) is a measure of the success or profitability of an investment. It is based in part on the savings or income received resulting from the investment. It is not, however, the intent of this paper to predict income for streaming media businesses. The income received from an investment in streaming media will be different for each company based on their revenue and pricing models and marketing programs. Nevertheless, it can be inferred that due to Burstware's better performance capabilities and lower costs, and, it is likely that ROI will be higher for a Burstware implementation than for conventional streaming. For a thorough analysis of ROI for your particular business, contact Burst.com marketing and sales at (415) 391-4455.

If, for example, an entertainment company similar to scenario A, implements streaming media with one of the technology strategies described in this paper, and anticipates an additional annual income due to new streaming capabilities ranging from $700,000 to $2,000,000, their likely return on investment for the first year is as follows:

Estimated Income from centralized streaming	$700,000	$1,000,000	1,500,000	000,000
Burstware ROI				
Burstware Costs	$623,650	$623,650	$623,650	$623,650
Net income (income -- costs)	$76,350	$376,350	$876,350	$1,376,350
Return on Investment (net income/costs)	12%	60%	141%	221%
Windows Media ROI				
Burstware Costs	$1,106,450	$1,106,450	$1,106,450	$1,106,450
Net income (income -- costs)	-$406,450	-$106,450	$393,550	$893,550
Return on Investment (net income/costs)	-3%	-10%	36%	81%

Table 17: Sample Burstware and Windows Media ROI

IX. CONCLUSIONS

Burst.com's Burstware was shown to be the most effective and efficient option for delivering high-quality, scalable streaming media solutions. Based on lab testing that simulated real-world behavior, test results showed that Burstware is superior to Windows Media in scalability, end-user quality and cost.

- Burstware uses hosted bandwidth more efficiently by utilizing the same bandwidth to serve more users over the same period of time.
- Burstware was able to utilized bandwidth more efficiently resulting in 25% less bandwidth required per month compared with Windows Media which leads in lower bandwidth costs and better quality for the user.
- Burstware users experience better quality multimedia even if networks are congested because they play the stream from a stored buffer.
- Burstware's built-in functionality such as load balancing, format independence and fault tolerance reduces points of failure and lowers cost.
- The savings for distributed streaming using Burstware were very significant. Test results showed that when compared to edge caching, Burstware allows for fewer servers to be placed in edge positions while still maintaining a high-quality user experience. This results in considerably less bandwidth hardware, software and costs.
- Burstware was also shown to be a more cost-effective option for conventional streaming. Up to 44% less costly than with Windows Media.

APPENDIX 1 – GLOSSARY

Bandwidth

The amount of data, expressed in bits per second, which can be transmitted in a fixed amount of time.

Broadband

A network connection that supports a high bandwidth. Broadband typically ranges from 300Kbps - 1 Mbps for home cable lines or digital services lines (DSL). Business broadband ranges from T1 speeds of 1.5 Mbps to T3 speeds of 45Mbps or more.

Bursting

A process of using surplus bandwidth to send large chunks of content, in excess of what is being viewed by the user, and storing the excess on the client-side cache.

Congestion

Any effects on a network that impede the transmission of information. Congestion on the Internet could be in the form of packet loss, latency, jitter, packet fragmentation, out-of-sequence packets, link faults or any combination of the above. These network effects are most often caused by routers.

Edge

Positions on the Internet that have been identified as "close" to the end-user. This could mean physical proximity (such as in the same city) or electronic proximity (such as on the same physical network). Servers on the edge that communicate with end-users often do not get affected by congestion as on the Internet backbone.

Edge Caching

A technique that improves the speed and usability of web sites by overcoming the problems of insufficient bandwidth and network congestion. Edge caching uses a distributed model to decentralize the servers and bring them "closer" to the end user. This may involve placing servers in multiple geographic locations and at multiple ISPs that have a large number of clients (known as "edge positions"). Each caching server maintains a copy of the multimedia files, and then redirects the client request to the server closest to the client.

Failover

The situation that occurs when one server goes down another server recovers and continues serving the stream to the user. Failover happens during playback and is transparent to the user.

Hit ratio

The percentage of requests in which the necessary files reside locally in the server's cache and do not require a connection back to the central server to retrieve it. Low cache hit ratios mean that often requested files are not stored in cache.

Hop

The trip that a data packet takes every time it is sent from one router to another on its way to its destination. More hops usually result in increased latency and potential for error.

Latency

The amount of time it takes for a data packet to reach its destination. Delay.

Microsoft Windows Media

Microsoft Corporation's media streaming services offering, which includes the Windows Media Player (for the client, or user, side), Windows Media Server (the server-component), and the Windows Media Tools (for content creation and authoring).

Packet Loss

A network event that contributes to congestion on a TCP/IP network. Packet loss can be caused by numerous factors, including excessive network load, router buffer overflow, bandwidth management policies, data corruption or infrastructure failure.

Point Of Presence (POP)

An access point to the Internet provided by ISPs. Clients connect to the Internet through an ISP's POP using dial-up, ISDN, Cable, DSL or leased lines.. POPs usually host digital/analog switching equipment, switches, routers and servers.

Return on Investment (ROI)

In this comparative cost analysis, the return on the investment in media streaming technology in each year of the three-year period is expressed as the cumulative total of the tangible benefits as a percentage of the cumulative total cost of ownership.

Streaming Media

Video and audio sent over the Internet or corporate network to a user's personal computer. It allows the user to start playing one portion of the stream while the rest of the file is being downloaded.

Total Cost of Ownership (TCO)

The total cost of ownership in this comparative analysis represents the total expenditure over the specified period of three years that a company will spend on either Microsoft Windows Media or on Burst.com technologies.

Video On Demand

Video content which may be viewed whenever the user needs it, anytime, anywhere.

APPENDIX 2 - LAB PARAMETERS AND SETTINGS

TEST METHODOLOGY

Both Burstware and Windows Media Services servers were installed on identical hardware with identical operating system settings. Media delivery services were tested in all of the default settings – i.e., no special tweaking to the services was done to improve performance. Logging was enabled in both products to simulate real-world settings and to capture test results for later analysis. Both Windows Media and Burstware servers were set to a maximum throughput equal to the "server bandwidth" parameter so that any additional requests that exceeded the pre-defined bandwidth would get the message, "Not enough bandwidth available, try again later." This prevented additional clients from saturating the server bandwidth and degrading the quality of the currently connected users.

TEST PARAMETERS

Scenario:	Distance Learning	Entertainment	Corporate Intranet
Stream Size	37 Kbps	128 Kbps	300 Kbps
Stream Length	5 minutes	5 minutes	5 minutes
Burstware Client Bandwidth	53 Kbps	256 Kbps	640 Kbps
Windows Media Client Bandwidth[2]	N/A[2]	N/A[2]	N/A[2]
Server Bandwidth	1 Mb	3 Mb	10 Mb
Duration of test	60 minutes	60 minutes	60 minutes

Table 18: Test lab scenario parameters

SOFTWARE SETTINGS

BURSTWARE WINDOWS MEDIA PLAYER BRIDGE SETTINGS

Warn on slow connection: False

Reconnect interval: 500 ms

Reconnect time: 20 sec

Pause when data starved: false

Seconds of data to buffer: 5 seconds

Buffer type: memory

Buffer size: 16MB

Backbuffer size: 256KB

[2] Windows Media plays the stream at the rate it was encoded at and therefore has no client bandwidth adjustment parameter.

Buffer directory: N/A

WINDOWS MEDIA PLAYER SETTINGS

Buffering: Use default buffering

SOFTWARE VERSIONS

Microsoft Windows 2000 Server build 2195

Microsoft Windows 2000 Professional build 2195

Burstware Server, Conductor and Media Player Bridge version 2.1

Microsoft Windows Media Services 4.1

Windows Media Player 6.4.09.1109

Shunra The Cloud version 2.1

APPENDIX 3 - COST DETAILS

ENTERTAINMENT INTERNET SERVICE PROVIDER TCO DETAILS

CENTRALIZED STREAMING

Inputs			
Average stream bit rate (in Kbps)	128		
Average stream length (in Minutes)	5		
Average visitors per month	3,500,000		
Average number of requests per second during normal peak usage time	350		
Minutes of non-ASF Content	300		
Variables			
	Burst	**Streaming**	**Notes**
Hardware			
Server platform	Dual Pentium III-733 512 MB RAM, 32GB RAID 0	Dual Pentium III-733 512 MB RAM, 32GB RAID 0	
Cost per Server	$6,000	$6,000	
Maximum number of streams per server at given bit rate	640	800	This number is an approximation! Actual data will have to be derived from testing and should be entered in this field based on the hardware platform and encoded bit rate.
Conductor platform	Pentium III-733, 128 MB RAM, 4GB HD	N/A	
Cost per Conductor	$3,500	N/A	
Load balancing hardware cost	$0	$25,000	Burst has load-balancing built-in.

Software			
Operating system	Windows 2000 Server	Windows 2000 Server	
Operating system cost	$1,000	$1,000	
Software version	Burstware 2.1 Server, Burstware 2.1 Conductor	Microsoft Windows Media Services 4.1	
Support			
Per-incident vendor support cost	$0	$195	
Estimated number of support calls	10	10	
Content Creation/Conversion			
Encoding cost (per minute)	$0	$15	Burst is format independent
Outputs			
Hardware			
Number of Servers needed	1	1	
Number of Conductors needed	1	N/A	
Total Server/Conductor cost	$9,500	$6,000	
Load balancing hardware	$0	$25,000	
Software			
Total operating system cost	$2,000	$1,000	
Total software licensing cost	$21,000	$0	
Hosting			
Total monthly data transfer (in GB)	16,021.7	16,021.7	
Monthly sustained bandwidth needed (in Mbps)	40.5	50.6	
Total monthly hosting cost	$49,000	$89,000	

Support			
Total support cost	$3,150	$1,950	Burst annual support is 15% of the SW cost.
Content Creation/Conversion			
Total encoding cost	$0	$4,500	
			Savings due to Burst
Total cost year 1	$623,650	$1,106,450	43.6%
Cumulative total for years 1 & 2	$1,214,800	$2,176,400	44.2%
Cumulative total for years 1, 2 & 3	$1,805,950	$3,246,350	44.4%

Table 19: Entertainment ISP scenario TCO details for centralized streaming

Inputs	
Average stream bit rate (in Kbps)	128
Average stream length (in Minutes)	5
Average visitors per month	3,500,000
Average number of requests per second during normal peak usage time	350
Estimated number of "edge" positions	30
Cache hit ratio (in %)	50%
Minutes of non-ASF Content	300

Variables			
	Burst Edge Serving	**Streaming Edge Caching**	**Notes**
Hardware			
Server platform	Sun UltraSPARC-II 450MHz, 512MB RAM, 4x 9GB SCSI RAID0, 100Mb NIC, Solaris 2.7	Sun UltraSPARC-II 450MHz, 512MB RAM, 4x 9GB SCSI RAID0, 100Mb NIC, Solaris 2.7	Most caching software runs on Unix and not Windows
Cost per Server	$14,000	$14,000	
Conductor platform	Pentium III-733, 128 MB RAM, 4GB HD	N/A	Can run on Windows or Unix
Cost per Conductor	$3,500	N/A	
Software			
Operating system	Solaris 2.7	Solaris 2.7	
Software version	Burstware 2.1 Server, Burstware 2.1 Conductor, Kasenna	Inktomi Traffic Server with Media IXT plugin	
Software licensing cost		$28,000	
Support			

Per-incident vendor support cost	$0	$195	
Estimated number of support calls	10	10	
Content Creation/Conversion			
Encoding cost (per minute)	$0	$15	
Outputs			
Hardware			
Number of edge positions needed	24	30	
Number of Conductors needed	1	N/A	
Total Server/Conductor cost	$339,500	$420,000	
Software			
Total software licensing cost	$272,000	$840,000	
Hosting			
Total monthly data transfer (in GB)	16,021.7	16,021.7	
Approximate monthly bandwidth per edge location	13.5	13.5	
Approximate monthly co-location and bandwidth cost	$624,000	$780,000	
Support			
Total support cost	$40,800	$1,950	Burst annual support is 15% of the SW cost.
Content Creation/Conversion			
Total encoding cost	$0	$4,500	
			Savings due to Burst
Total cost year 1	$8,140,300	$10,626,450	23.4%
Cumulative total for years 1 & 2	$15,669,100	$19,988,400	21.6%
Cumulative total for years 1, 2 & 3	$23,197,900	$29,350,350	21.0%

Table 20: Entertainment ISP Scenario TCO details for distributed streaming

DISTANCE-LEARNING TCO DETAILS

CENTRALIZED STREAMING

Inputs	
Average stream bit rate (in Kbps)	37
Average stream length (in Minutes)	30
Average visitors per month	100,000
Average number of requests per second during normal peak usage time	350
Minutes of non-ASF Content	500

Variables			
	Burst	Streaming	Notes
Hardware			
Server platform	Dual Pentium III-733 512 MB RAM, 32GB RAID 0	Dual Pentium III-733 512 MB RAM, 32GB RAID 0	
Cost per Server	$6,000	$6,000	
Maximum number of streams per server at given bit rate	2,215	2,768	This number is an approximation.
Conductor platform	Pentium III-733, 128 MB RAM, 4GB HD	N/A	
Cost per Conductor	$3,500	N/A	
Load balancing hardware cost	$0	$25,000	Burst has load-balancing built-in.
Software			
Operating system	Windows 2000 Server	Windows 2000 Server	
Operating system cost	$1,000	$1,000	
Software version	Burstware 2.1 Server, Burstware 2.1 Conductor	Microsoft Windows Media Services 4.1	

Support			
Per-incident vendor support cost	$0	$195	
Estimated number of support calls	10	10	
Content Creation/Conversion			
Encoding cost (per minute)	$0	$15	Burst is format independent
Outputs			
Hardware			
Number of Servers needed	1	1	
Number of Conductors needed	1	N/A	
Total Server/Conductor cost	$9,500	$6,000	
Load balancing hardware	$0	$25,000	
Software			
Total operating system cost	$2,000	$1,000	
Total software licensing cost	$0	$0	
Hosting			
Total monthly data transfer (in GB)	793.9	793.9	
Monthly sustained bandwidth needed (in Mbps)	2.0	2.5	
Total monthly hosting cost	$11,500	$11,500	
Support			
Total support cost	$0	$1,950	Burst annual support is 15% of the SW cost.
Content Creation/Conversion			
Total encoding cost	$0	$7,500	

			Savings due to Burst
Total cost year 1	$149,500	$179,450	16.7%
Cumulative total for years 1 & 2	$287,500	$319,400	10.0%
Cumulative total for years 1, 2 & 3	$425,500	$459,350	7.4%

Table 21: Distance-learning scenario TCO details for centralized streaming

Inputs: Distance Learning Scenario			
Average stream bitrate (in Kbps)	37		
Average stream length (in Minutes)	30		
Average visitors per month	100,000		
Average number of requests per second during normal peak usage time	350		
Estimated number of "edge" positions	30		
Cache hit ratio (in %)	50%		
Minutes of non-ASF Content	300		
	Burst Edge Serving	**Streaming Edge Caching**	**Notes**
Hardware			
Server platform	Sun UltraSPARC-II 450MHz, 512MB RAM, 4x 9GB SCSI RAID0, 100Mb NIC, Solaris 2.7	Sun UltraSPARC-II 450MHz, 512MB RAM, 4x 9GB SCSI RAID0, 100Mb NIC, Solaris 2.7	Most caching software runs on Unix and not Windows
Cost per Server	$14,000	$14,000	
Conductor platform	Pentium III-733, 128 MB RAM, 4GB HD	N/A	Can run on Windows or Unix
Cost per Conductor	$3,500	N/A	
Software			
Operating system	Solaris 2.7	Solaris 2.7	
Software version	Burstware 2.1 Server, Burstware 2.1 Conductor, Kasenna	Inktomi Traffic Server with Media IXT plugin	
Software licensing cost		$28,000	
Support			
Per-incident vendor support cost	$0	$195	

Estimated number of support calls	10	10	
Content Creation/Conversion			
Encoding cost (per minute)	$0	$15	
Outputs			
Hardware			
Number of edge positions needed	24	30	
Number of Conductors needed	1	N/A	
Total Server/Conductor cost	$339,500	$420,000	
Software			
Total software licensing cost	$272,000	$840,000	
Hosting			
Total monthly data transfer (in GB)	793.9	793.9	
Approximate monthly bandwidth per edge location	2.3	2.3	
Approximate monthly co-location and bandwidth cost	$276,000	$345,000	
Support			
Total support cost	$40,800	$1,950	Burst annual support is 15% of the SW cost.
Content Creation/Conversion			
Total encoding cost	$0	$4,500	
			Savings due to Burst
Total cost year 1	$3,964,300	$5,406,450	26.7%
Cumulative total for years 1 & 2	$7,317,100	$9,548,400	23.4%
Cumulative total for years 1, 2 & 3	$10,669,900	$13,690,350	22.1%

Table 22: Distance-learning scenario TCO details for distributed streaming

Corporate Communications TCO Details

Centralized Streaming

Inputs: Corporate communications scenario	
Average stream bit rate (in Kbps)	300
Average stream length (in Minutes)	30
Average visitors per month	75,000
Average number of requests per second during normal peak usage time	350
Minutes of non-ASF Content	400

Variables			
	Burst	Streaming	Notes
Hardware			
Server platform	Dual Pentium III-733 512 MB RAM, 32GB RAID 0	Dual Pentium III-733 512 MB RAM, 32GB RAID 0	
Cost per Server	$6,000	$6,000	
Maximum number of streams per server at given bit rate	274	342	This number is an approximation.
Conductor platform	Pentium III-733, 128 MB RAM, 4GB HD	N/A	
Cost per Conductor	$3,500	N/A	
Load balancing hardware cost	$0	$25,000	Burst has load-balancing built-in.
Software			
Operating system	Windows 2000 Server	Windows 2000 Server	
Operating system cost	$1,000	$1,000	
Software version	Burstware 2.1 Server, Burstware	Microsoft Windows Media	

	2.1 Conductor	Services 4.1	
Support			
Per-incident vendor support cost	$0	$25,000	Windows Premier support would be used
Estimated number of support calls	10	1	
Content Creation/Conversion			
Encoding cost (per minute)	$0	$15	Burst is format independent
Output			
Hardware			
Number of Servers needed	2	2	
Number of Conductors needed	1	N/A	
Total Server/Conductor cost	$15,500	$12,000	
Load balancing hardware	$0	$25,000	
Software			
Total operating system cost	$3,000	$2,000	
Total software licensing cost	$51,270	$0	
Hosting			
Total monthly data transfer (in GB)	4,828.0	4,828.0	
Monthly sustained bandwidth needed (in Mbps)	12.2	15.3	
Total monthly hosting cost	$26,000	$32,500	
Support			
Total support cost	$7,690	$25,000	Burst annual support is 15% of the SW cost.

Content Creation/Conversion			
Total encoding cost	$0	$6,000	
			Savings due to Burst
Total cost year 1	$389,460	$460,000	15.3%
Cumulative total for years 1 & 2	$709,150	$875,000	19.0%
Cumulative total for years 1, 2 & 3	$1,028,841	$1,290,000	20.2%

Table 23: Corporate communications scenario TCO details for centralized streaming

Inputs

Average stream bitrate (in Kbps)	300	
Average stream length (in Minutes)	5	
Average visitors per month	1,000,000	
Estimated number of "edge" positions	30	
Cache hit ratio (in %)	50%	
Minutes of non-ASF Content	300	Existing MPEG, AVI, MP3, QuickTime or other content
Anticipated income or savings for year 1	$0	
Anticipated income or savings for year 2	$0	
Anticipated income or savings for year 3	$0	

Variables

	Burst Edge Serving	Streaming Edge Caching	Notes
Hardware			
Server platform	Sun UltraSPARC-II 450MHz, 512MB RAM, 4x 9GB SCSI RAID0, 100Mb NIC, Solaris 2.7	Sun UltraSPARC-II 450MHz, 512MB RAM, 4x 9GB SCSI RAID0, 100Mb NIC, Solaris 2.7	Most caching software runs on Unix and not Windows
Cost per Server	$14,000	$14,000	
Conductor platform	Pentium III-733, 128 MB RAM, 4GB HD	N/A	Can run on Windows or Unix
Cost per Conductor	$3,500	N/A	

Software		
Operating system	Solaris 2.7	Solaris 2.7
Software version	Burstware 2.1 Server, Burstware 2.1 Conductor, Kasenna ??????	Inktomi Traffic Server with Media IXT plugin
Software licensing cost		$28,000
Hosting		
Monthly co-location and bandwidth cost	***See "Co-Location Pricing Model" Worksheet***	***See "Co-Location Pricing Model" Worksheet***
Support		
Per-incident vendor support cost	$0	$195
Estimated number of support calls	10	10
Content Creation/Conversion		
Encoding cost (per minute)	$0	$15
Outputs		
Hardware		
Number of edge positions needed	24	30
Number of Conductors needed	1	N/A
Total Server/Conductor cost	$339,500	$420,000
Software		
Total software licensing cost	$272,000	$840,000
Hosting		

Total monthly data transfer (in GB)	10,728.8	10,728.8	
Approximate monthly bandwidth per edge location	3.9	3.9	
Approximate monthly co-location and bandwidth cost per edge location	$276,000	$345,000	
Support			
Total support cost	$40,800	$1,950	Burst annual support is 15% of the SW cost.
Content Creation/Conversion			
Total encoding cost	$0	$4,500	
			Savings due to Burst
Total cost year 1	$3,964,300	$5,406,450	26.7%
Cumulative total for years 1 & 2	$7,317,100	$9,548,400	23.4%
Cumulative total for years 1, 2 & 3	$10,669,900	$13,690,350	22.1%

ROI year 1	-100%	-100%	
ROI year 2	-100%	-100%	
ROI Year 3	-100%	-100%	