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Eyeball AnyBandwidth™ Technology

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Abstract – The AnyBandwidth™ Technology is Eyeball's core technology. The main features of AnyBandwidth include adaptability to network and CPU, low computational cost, and transmission error resilience. It powers Eyeball's video instant messaging application, Eyeball Chat™, as well as our enterprise video communications solutions, Eyeball Video Communications Server, Group Server Extension, Video Messaging Server, and the Eyeball Communicator client.

Overview

The Eyeball AnyBandwidth Technology is the revolutionary adaptive video technology developed at Eyeball Networks for real-time one-way and two-way streaming audio-video applications. It enables audio-video communications among multiple clients and/or servers having heterogeneous processor capacities and network connections, and/or network connections with dynamically changing properties. AnyBandwidth provides optimized video quality (such as frame rate, picture resolution, and sharpness) to each user based on the available network bandwidth and processing power.

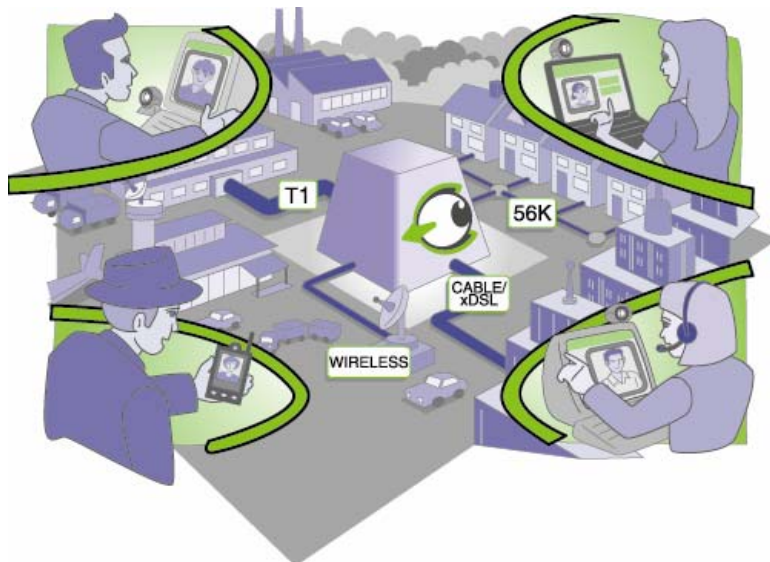


Figure 1: Eyeball AnyBandwidth™ Technology supports a wide variety of hosts and network connections. It dynamically adapts video quality of each client to the actual networking conditions and available hardware resources.



Figure 1 illustrates a video communications system using the Eyeball AnyBandwidth Technology supporting multiple clients with highly varying performance levels and network connections. The key feature of the AnyBandwidth Technology is that the video quality is individually optimized for each client according to the available resources at the client's end. Thus clients connecting via T1 lines, cable modems, or DSL technology, can decode high quality video at high frame rate, and, at the same time, clients connecting via 56k dial-up-modems or wireless connections send or receive motion video at lower quality and lower frame rate. For example, when resources are abundant, clients receive full-motion and full-quality video (e.g., 352x288 pixels at 30 frames/sec). However, in the case of limited network bandwidth and/or CPU power, clients receive gracefully and optimally reduced video (e.g., 88x72 pixels at 7.5 frames/sec) without experiencing any blackouts, large delays, or blocking artifacts.

Current Technologies

Traditionally, video streaming solutions are based on the so-called *switching* technology. In this system, the video source provides multiple copies of the same video at different frame rates and quality levels. Each copy is independently transmitted and decompressed as shown in Figure 2.

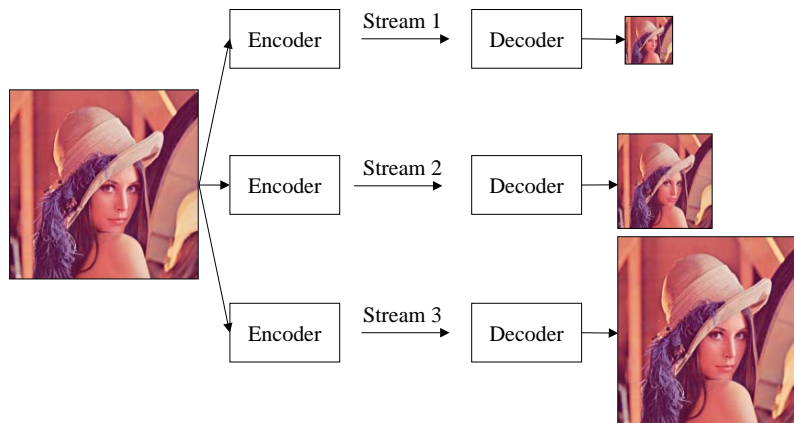


Figure 2: Traditional switched video streaming system.

The major disadvantages of such a system include:

- It requires several compressors to run in parallel, resulting in large CPU overhead.
- If there are multiple receivers with different networking and hardware capabilities, multiple streams, each at a different frame rate and/or quality, must be transmitted independently resulting in large network overhead.
- Adaptation to network conditions and hardware resources must be *source-driven*, i.e., based on some feedback from the client. The video source must select the stream to be transmitted. This scheme works well for one-to-one communications but is clearly not applicable for many-to-many communications.

Highly Scalable Encoding

Traditional video compression standards such as MPEG-2 or H.263 are not suitable for scalable video applications. On the other hand, the AnyBandwidth Technology is based on patent-pending technology providing scalable video representation.

Eyeball AnyBandwidth provides frame rate and picture quality scalability (resolution and sharpness) that is designed to support both network bandwidth availability and processing capacity adaptation. This technology can be used to support a wide variety of clients with CPUs ranging from Pentium 166 MHz MMX to Pentium 4 1.5 GHz and beyond, and network bandwidth ranging from 10 kbps to 1 Mbps. Eyeball AnyBandwidth™ is the only video technology in the industry that can support such a wide range of processors and network connections.

The block diagram of Eyeball AnyBandwidth scalable video compression system is shown in Figure 3. The scalable compressor produces multiple video layers. During transmission, each video layer is transmitted in a separate substream. The video quality at the receiver depends on the number of video layers used in the decomposition. Decompressing more video layers results in better video quality.

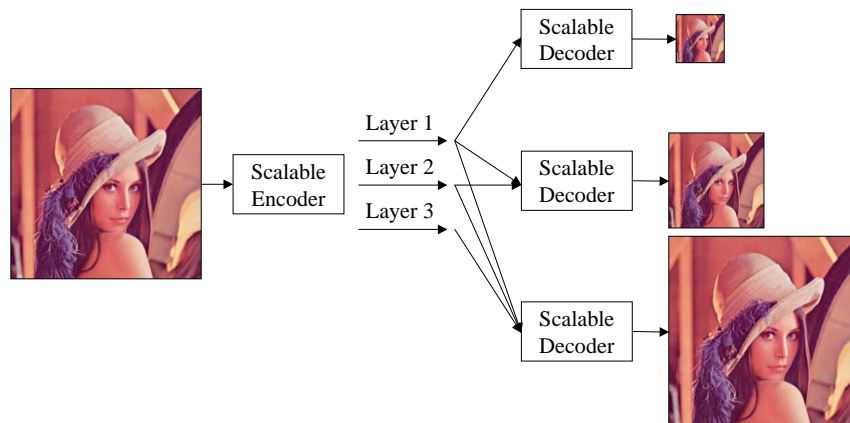


Figure 3: Eyeball AnyBandwidth™ scalable video streaming.

The advantages of the AnyBandwidth Technology include:

- No CPU power is wasted since only one compressor is required.
- Aggregate output bandwidth is optimized by using non-overlapping sub-streams; clients only receive video layers that can be supported by their network connections and processing hardware.
- Adaptation to network conditions and hardware resources is *client-driven*, i.e., each client decides how many video layers to receive and process. This scheme works well with both one-to-one and many-to-many communications.

The AnyBandwidth Compression Engine: How It Works

The block diagram of the Eyeball AnyBandwidth compression engine is shown in Figure 4. The developed technique efficiently exploits the temporal redundancy inherent in video by determining parts of the frame to be compressed. Then, block-based discrete cosine transform (DCT) is applied followed by our novel data reorganization technique. A subset of DCT coefficients is selected, which has significant contribution to the video quality. As seen in Figure 4, only a small fraction of DCT coefficients is significant and needs to be transmitted to the client resulting in very high compression ratio. During compression, the significance information is efficiently stripped among multiple video layers.

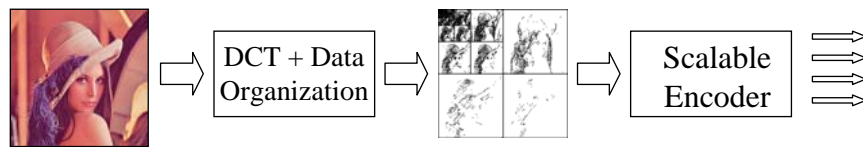


Figure 4: Eyeball AnyBandwidth™ compression engine.

The block diagram of the AnyBandwidth decompression engine is shown in Figure 5. The decoder receives a subset of video layers based on the network connection and available processor capacity, and performs the reverse operation of the compression engine.

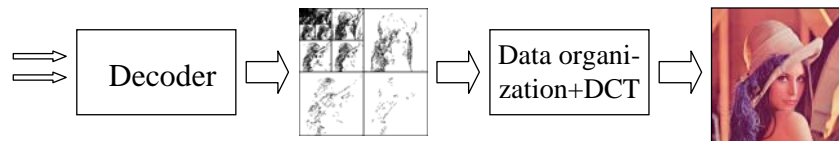


Figure 5: Eyeball AnyBandwidth™ decompression engine.

Eyeball AnyBandwidth Compression Performance

The performance of the AnyBandwidth Technology is illustrated for typical video communications scenarios. Figure 6 illustrates the adaptation capability of AnyBandwidth Technology ranging from bit rate of 10 kbps at 2.5 frames/sec to bit rate of 200 kbps at 10 frames/sec.

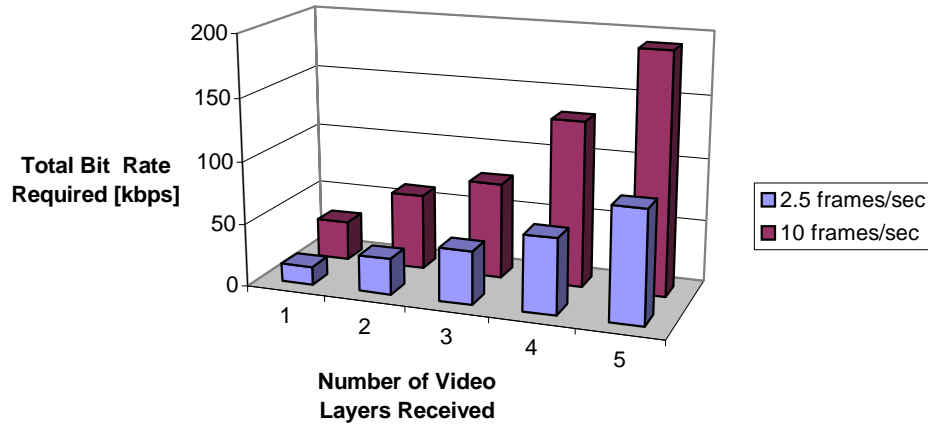


Figure 6: Better video quality requires more video layers to be received demanding higher bandwidth.

Visual comparison of decompressed images is shown in Figure 7. The uncompressed video would require 3 Mbps, which easily overwhelms even high-speed networks. With the AnyBandwidth Technology, bit rates ranging between 10 kbps and 200 kbps and frame rates ranging between 2.5 frames/sec and 10 frames/sec can be obtained by partially decompressing only one video stream.



Figure 7: Visual performance comparison with the AnyBandwidth Technology. (a) Original image. (b) Decompressed image at 10 frames/sec, 200 kbps. (c) Decompressed image at 5 frames/sec, 68 kbps. (d) Decompressed image at 2.5 frames/sec, 10 kbps.

Applications

The Eyeball AnyBandwidth Technology is a novel enabling technology for interactive and distributive audio-video communications among multitude of clients having a wide range of computers with a variety of network connections. It is suitable for applications ranging from low bit rate interactive videophony and video chatting through mobile audio-video communications over error-prone wireless links to broadcast quality video streaming over high bandwidth networks. Here is a short list of application areas where the Eyeball AnyBandwidth is appropriate:

- Web-based video chat system:** The AnyBandwidth Technology provides high-performance software-only compression and decompression engines for Web-based video chatting applications. Multiple clients can join in a video chat session, and the

AnyBandwidth Technology will dynamically optimize the video quality for each client. Thus users with high bandwidth connection will send and receive high quality audio-video signals, whereas users with low bandwidth connection will send and receive lower quality audio-video signals.

- **Ubiquitous video streaming with optimized quality:** The AnyBandwidth Technology opens up opportunities to reach a multitude of users with variety of computers and time-varying network connections. Multiple clients with different levels of resources can be served using the same video source stream. Each client receives video quality optimized for the available resources at the client.
- **Wireless video access:** Second generation wireless systems provide bandwidth in the range of 10 kbps. At this bit rate, the AnyBandwidth Technology provides the needed extremely high compression ratio. Third generation wireless systems are expected to provide at least 144 kbps bandwidth. At this bit rate, the AnyBandwidth Technology enables two-way audio-video communications. Suppose that a user receives a video call through his/her mobile phone while driving to work. The call is received through a wireless connection, resulting in low quality video at low frame rate, which makes optimal use of the current hardware resources. However, as soon as the user steps into his/her office, the call is rerouted to his/her LAN, and the AnyBandwidth Technology dynamically upgrades the picture quality and refresh rate.
- **Networked games with live video:** The AnyBandwidth Technology is also well applicable for networked multiplayer games, such as first person shooter games and card or board games, where the players' interaction is extended with live video experience. Here, it enables multiple users to participate in the game and get the best possible experience depending on the system state.
- **Advertisement:** Current on-line advertisements are mainly based on animated GIF images. Each animated GIF file contains a few still images that are played back by the browser. Imagine that this animated GIF image sequence is replaced with motion video and audio. A key feature is that the AnyBandwidth Technology enables dynamic adjustment of advertisement data-rate based on the available bandwidth in order to avoid user dissatisfaction due to slowing down for advertisement. When a user is not using much bandwidth (e.g., waiting for search results, reading a web page, etc.), more bit rate can be spent on transmitting advertisement material. When the user is actively surfing and downloading media-rich content requiring high bit rate, less bandwidth is spent on advertisement.

Features of Eyeball AnyBandwidth Technology

The Eyeball AnyBandwidth Technology provides the following desirable features for networked video communications:

- **Scalable compression with quality adaptation:** The AnyBandwidth Technology provides frame rate and picture quality scalability that can be used for both network bandwidth and processing capacity adaptation. Current video compression standards such as MPEG-1 and H.263 do not support scalable video. Although MPEG-2 and H.263+ provide limited

support for quality scaling, most implementations do not support it. Supporting multi-stream video using these standards not only increases the computational requirement of the compressor, it also lowers the compression efficiency significantly. On the other hand, the AnyBandwidth Technology provides inherent support for scalable compression without introducing any significant performance degradation.

- **Low computational cost:** Both the AnyBandwidth compression engine and decompression engines have low, approximately equal computational complexity that enables software-only implementation. On the other hand, the compressor of current standards such as MPEG-2 and H.263 requires about ten-fold more computation than the decompressor. This high computational complexity makes software-only encoding very difficult.
- **Transmission error resilience:** The AnyBandwidth Technology is robust against packet loss and variable delay. Although primarily developed for the Internet, the AnyBandwidth Technology can also deliver optimized video quality over wireless connections. On the other hand, current standards (e.g., H.263, MPEG, etc.) are highly transmission error sensitive and are therefore not well suited for networked multimedia applications, especially in the wireless scenario.
- **Based on standard transport system:** The transport protocol of the AnyBandwidth Technology is based on international standards such as RTP and UDP.
- **Based on IP Multicast:** The AnyBandwidth Technology uses IP Multicast technology for video streaming in order to provide efficient video communications to thousands of clients. When the network is not multicast capable, geographically distributed Eyeball Group Server Extension provide efficient video communications.

Additional Information

Eyeball Networks is a leader in video communications software infrastructure for application developers, Communication Service Providers, enterprises and consumers. Eyeball's AnyBandwidth™ was the first adaptive media delivery technology that guarantees the best possible video quality for any Internet connection, on any device. Its award-winning software platform enables rapid development and deployment of scalable, cost-efficient video communications systems. Founded in 1997, Eyeball Networks is a privately held company headquartered in Vancouver, BC, with a research facility in Ottawa, ON, Canada.

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