H.264 & IPTV Over DSL

Enabling New Telco Revenue Opportunities

The new H.264/MPEG-4 AVC video coding standard enables telcos and ISPs to deliver high-quality video and television over digital subscriber lines (DSL), creating new revenue-generating opportunities.

Executive Summary

Telcos face a growing challenge from their competitors in the cable television operator and wireless telephone industries. Metropolitan cable service operators (MSOs) offer new Internet access and voice over IP (VoIP) telephone services—along with digital video and television—that encroach on the market and revenue of telcos. And consumers are choosing the convenience of personal wireless telephones over traditional wireline service. Telcos need a competitive edge that leverages their industry-leading position with broadband digital subscriber line (DSL) technology to offer new services that effectively compete with cable and give them new revenue opportunities with their customers. The IP video services (IPTV) market presents attractive revenue-generating forecasts, and a new video compression standard, H.264/AVC, enables a compelling solution for telcos to engage in IPTV.

The H.264/AVC standard lets telcos deploy broadcast- and DVD-quality video content over their existing DSL-based IP access networks to help them effectively compete with cable and wireless operators. For those telcos that have offered MPEG-2-based digital video services to their highest-speed DSL customers, they can expand their delivery market, because H.264/AVC cuts the bandwidth requirement for digital video delivery in half, effectively doubling the reach of their video services. IPTV can be deployed for less than traditional MPEG-2 deployments, and cost-effective H.264/AVC solutions are available today.

This paper introduces IPTV, the H.264/AVC standard, and the benefits for telcos.

Contents

Telcos Face Major Market Challenges

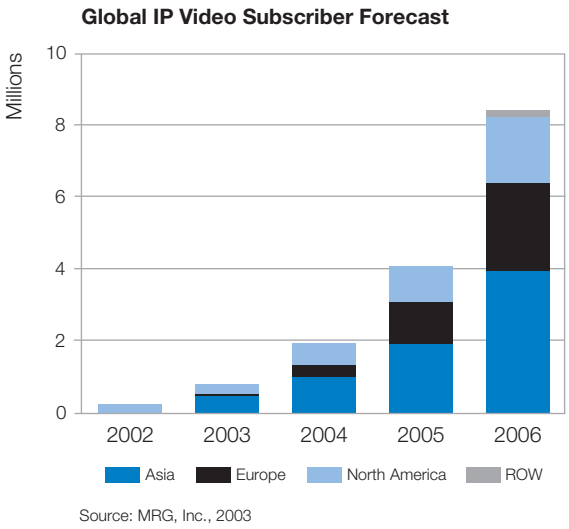
The Internet has become an essential part of every home and a must-have for business. While incumbent and competitive local exchange carriers (ILECs/CLECs) have dominated the Internet access market because of their existing copper infrastructure and digital subscriber line (DSL) technology, telephone companies (telcos) now face tough competition to maintain their market share. Cable television service providers, in an effort to boost their average revenue per user (ARPU), now offer competitive, high-speed data services in addition to another home and business staple—MPEG-2-based digital video and high-definition television (HDTV). Customers find a single source for both high-speed data and digital video services very attractive. And the telcos suffer because of it.

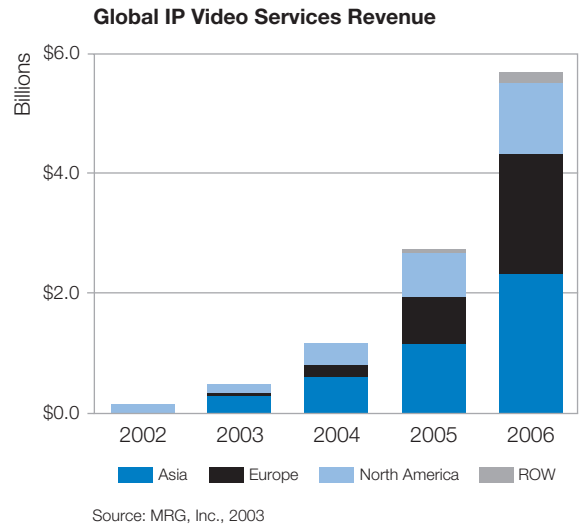
Of course, a very few xDSL customers enjoy one of the fastest and most cost-competitive Internet access services available—from 3 to 8 Mbps—which is easily capable of delivering the MPEG-2 bandwidth requirement of 2 Mbps for broadcast-quality digital video. But the short DSL loop length limits the total available market (TAM) at these speeds. More DSL customers can get data rates as fast as cable at 1.5 Mbps, and, while this speed makes it possible to watch Internet streaming video based on the MPEG-4 Simple Profile (MPEG-4 SP) codec in real time, 1.5 Mbps is not adequate to deliver broadcast-quality MPEG-2 video streams. With a very limited TAM, the investments telcos require to deliver video over DSL is not easily justifiable using MPEG-2. Plus, two other market phenomena add to the telcos' challenges and catalyze the need for new services that boost ARPU and grow market share.

First, major metropolitan cable service providers are beginning to encroach on the telcos' bread and butter revenues, deploying voice services over their existing cable infrastructure using voice over IP (VoIP) technology. These MSOs offer customers a cost-competitive single source for digital video, Internet access and gaming, and voice services. Second, increasingly, households are dropping their traditional wireline service and moving to wireless-only voice services for the convenience of always having access to a personal phone line, plus wireless Internet access. A new portability law in the United States, allowing customers to take their long-standing household phone number to the new service, makes this migration even more attractive.

The telcos face a significant challenge. In an effort to continue to produce revenue-generating services that boost ARPU and retain their market share, telcos are focusing their efforts on a new video codec, H.264/MPEG-4 Advanced Video Coding (or just H.264/AVC). This new video encoding/decoding scheme enables a compelling solution through IPTV-DVD-quality video services over DSL and the Internet. (See page 10, "H.264/MPEG-4 AVC-The IPTV Enabling Technology Standard.")

Figure 1. IP Video Services market is expected to offer significant revenue opportunities to service providers (Source: MRG, Inc., 2003)





IPTV – New Revenue Stream Opportunity for Telcos

The home continues to grow more digital with each new round of technology development. Consumers add MP3 players, set-top boxes (STBs), personal video recorders (PVRs), TiVo* devices, digital cameras, and HDTVs to their cache of digital entertainment devices. Plus, they create wireless home networks to connect their components to each other and to a new generation of multimedia STBs, desktop PCs, and laptop PCs designed for the digital home. The digital home is not just an idea of the future; it's here today. And in many households, the connection to the Internet to share pictures, download music and MPEG-4 videos, and stay in touch with family and friends is DSL technology. With H.264/AVC, the next advance for the digital home is IPTV.

IP Video Services Market Heats Up

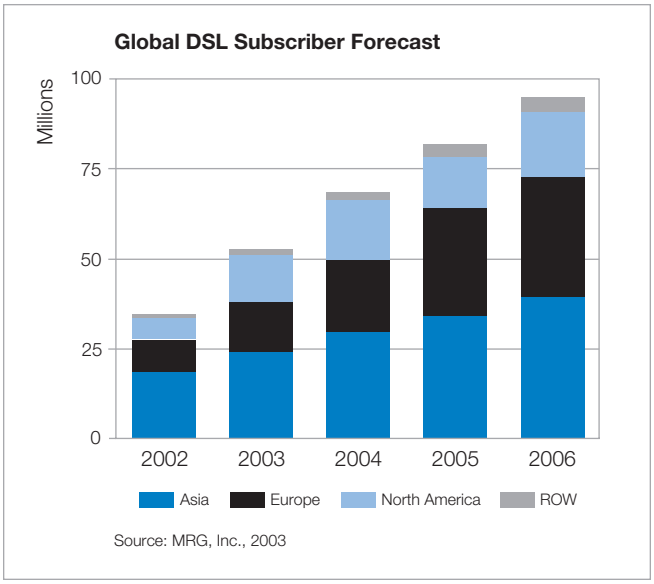
IP video, viewable on TVs, STBs, and PCs, is expected to become a major part of any home's entertainment line-up. According to Multimedia Research Group, Inc. (MRG, Inc.), worldwide IP video services subscriptions are expected to more than quadruple, from under 2 million subscribers in 2004 to over 8 million users in 2006—just two years (Figure 1).[1] This growth indicates a significant trend. And, with market revenue forecasts climbing from $1 billion US to nearly $6 billion US in the same time frame (Figure 1), it offers a market opportunity for telcos ready to invest in the future using H.264/AVC.

H.264/AVC Enables IPTV Over DSL

H.264/AVC cuts in half the bandwidth required to deliver full-screen DVD-quality digital video to consumers, and it reduces standard television quality digital transmission bandwidth requirements to 700 kbps—both well within the capabilities of a 1.5 Mbps DSL loop. Using new H.264/AVC delivery platforms and standard PCs or STBs, telcos can offer exciting IP video services—video-on-demand (VOD), local, national, and premium television programming, gaming, music, and, even interactive television—to their home and business customers using their existing copper infrastructure.

With DSL technology, the telcos hold a significant advantage by delivering IPTV to more of the masses than cable operators. While cable and satellite Internet access is encroaching on the telcos long-held dominance, DSL is still the leading broadband technology that users subscribe to around the world.[2] According to the DSL Forum (www.dslforum.org), 55 million Internet users worldwide use DSL; 25 million new subscribers alone were added from September 2002 to September 2003. The growth trend is expected to continue, with subscriptions reaching nearly 100 million users worldwide by 2006 (Figure 2). H.264/AVC reduces the barriers to entry for telcos, who can offer more services than cable operators.

Figure 2. The number of DSL users is expected to continue to rise through 2006 (Source: MRG, Inc., 2003)



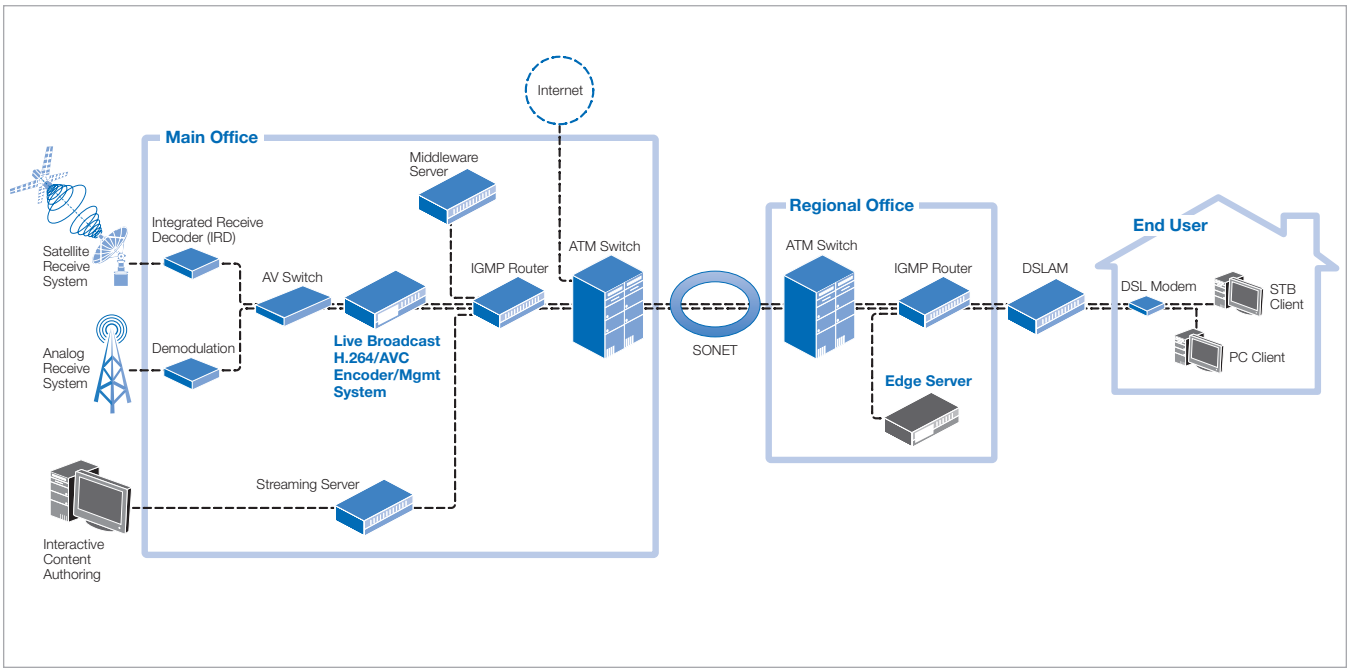
Delivering Video Services Over DSL

Similar to MPEG-2, H.264/AVC requires encoding and decoding technology to prepare the video signal for transmission and then read it at the customer's receiver (STB and TV/monitor, or PC). In fact, H.264/AVC can use transport technologies compatible with MPEG-2, simplifying an upgrade from MPEG-2 to H.264/AVC to help protect the investment in MPEG-2 some companies have already made, while enabling transport over TCP/IP and wireless. A significant difference, however, is that H.264/AVC does not require the expensive, often proprietary encoding and decoding hardware that MPEG-2 depends on, making it faster and easier to deploy H.264/AVC solutions using standards-based processing systems, servers, and STBs. This also allows service providers to deliver content to devices for which MPEG-2 cannot be used, such as PDA and digital cell phones. H.264/AVC is ideal for, but not limited to, Video Services over DSL; it increases the ground of applications based on a common video format.

The H.264/AVC encoder system in the main office (Figure 3) turns the raw video signals received from content providers into H.264/AVC video streams. The streams can be captured and stored on a video server at the headend, or sent to a video server at a regional or central office (CO), for video-on-demand services. The video data can also be sent as live programming over the network. Standard networking and switching equipment routes the video stream, encapsulating the stream in standard network transport protocols, such as ATM. A special part of H.264/AVC, called the Network Abstraction Layer (NAL), enables encapsulation of the stream for transmission over a TCP/IP network, such as a telco's DSL Internet access services network.

When the video data reaches the customer's site, it is routed to the client through a DSL modem and the customer's local network (wired or wireless). An STB client decodes the stream for display on a television or monitor, while a PC client decodes the data using a plug-in for the client's video player (Real Player*, Windows* Media Player*, etc.).

Figure 3. IP video over DSL architecture



Maximize Opportunity, Minimize Investment

H.264 opens the door to new opportunities and reduces operating and deployment costs when compared to MPEG-2. There are several reasons:

- H.264 compresses video more efficiently, cutting transmission costs over satellite or terrestrial links.
- Density of services over existing DSL loops is high: two standard-quality video streams can be transmitted over a single 1.5 Mbps loop (Figure 4). Customers can watch (and telcos can bill for) two video-on-demand streams at the same time.
- More content can be transmitted on longer loops—to more customers—raising the TAM for IPTV (Figure 4). Where MPEG-2 could only reach customers in a 9,000 ft^2 service area per CO, H.264/AVC video streams can reach customers in a 16,000 ft^2 service area per CO.
- A larger service area can be reached without deploying costly remote amplifiers (Figure 5).
- MPEG-4 interactivity capabilities let telcos expand ARPU with value-added interactive services embedded in video streams.
- H.264/AVC technology can be deployed on commercially available, industry-standard hardware instead of expensive proprietary or RISC-based systems, lowering acquisition costs and the costs of scaling technology to expand services.
- H.264/AVC is also part of the upcoming 3GPPv6 specifications. With the use of joint technologies, UDP or TCP/IP and H.264, there is a common ground for greater interaction between the home and mobile devices.

Figure 4. H.264/AVC enables reaching greater distances over DSL with more content (Source: Envivio, Inc., 2003)

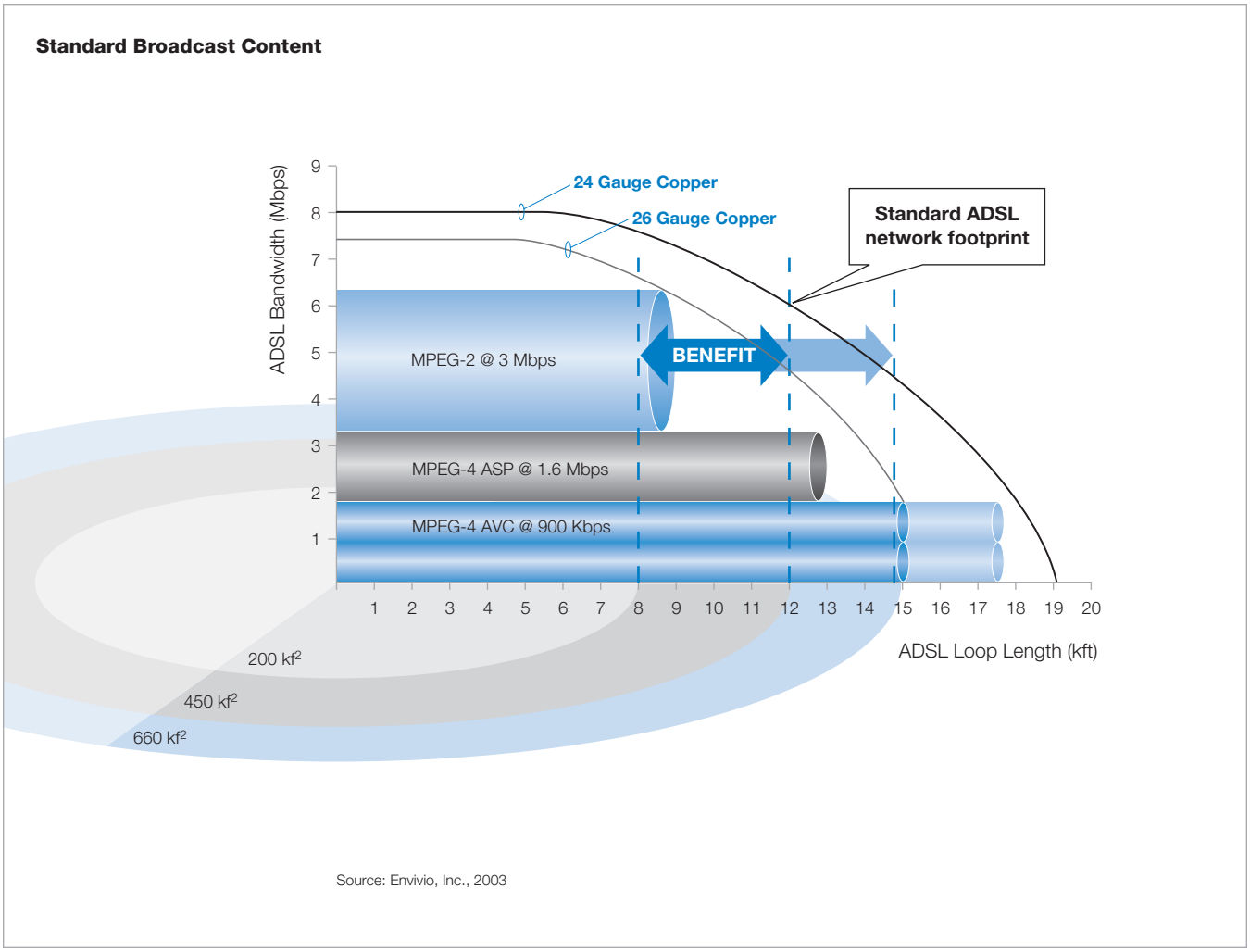
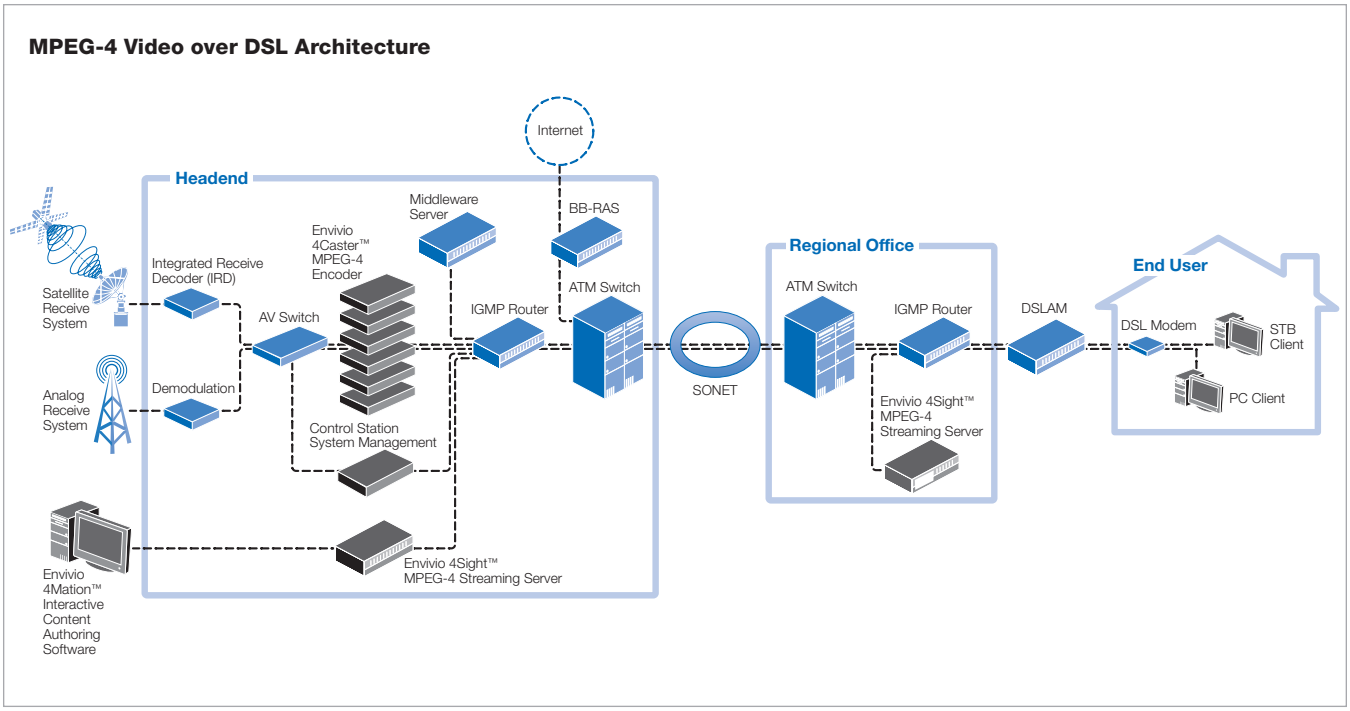


Figure 5. Envivio H.264/AVC delivery solution for deploying IPTV services over DSL



Enabling Technologies

H.264/AVC can be deployed using commercially available, industry-standard hardware. Envivio offers several H.264/AVC solutions on Intel® Architecture-based platforms. Envivio chose Intel for its performance, cost, and industry-leadership position.

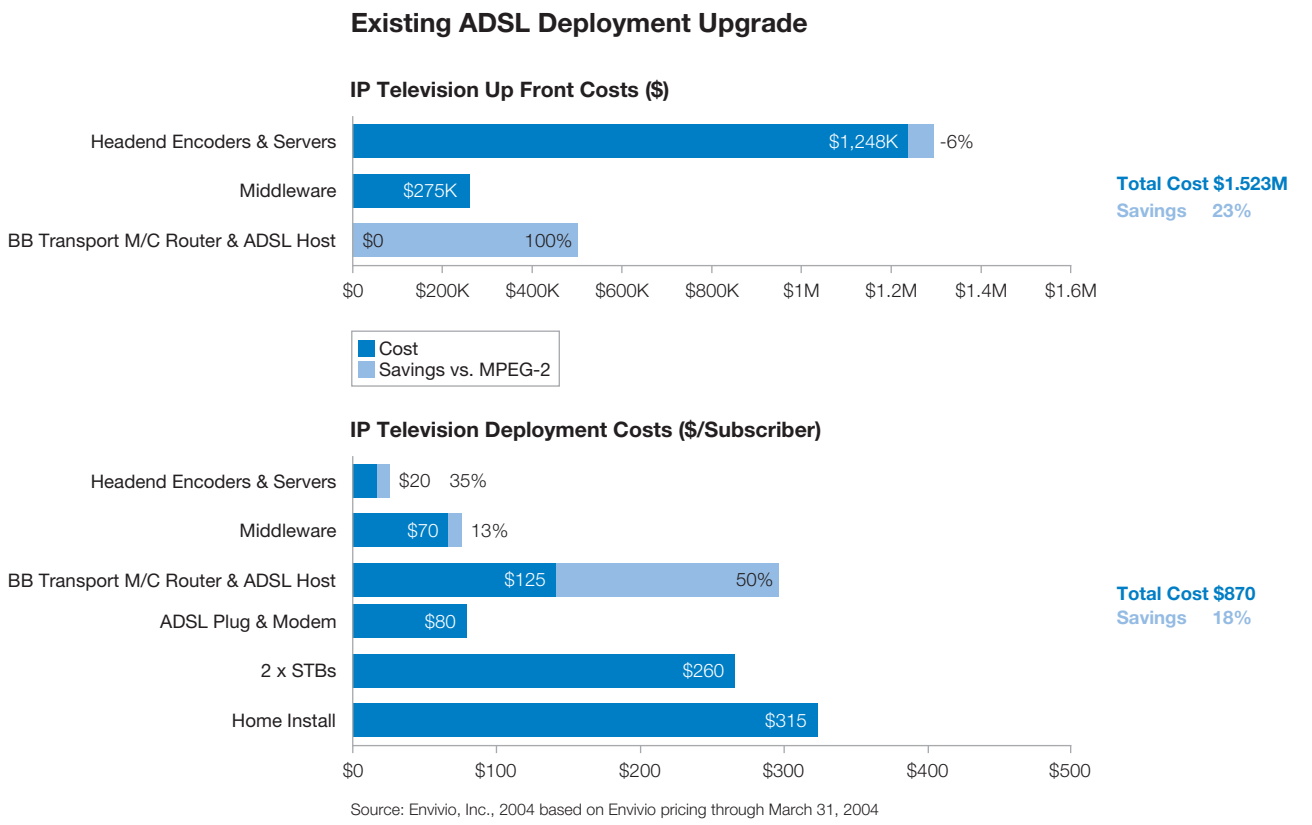
Envivio™ IPTV Technologies

Envivio offers a broad range of broadcast-quality H.264/AVC encoders, video servers, authoring tools, players, and management systems for telcos to provide digital television and interactive media services. Envivio's integrated H.264/AVC solutions are designed for acquiring, encoding, and storing content suitable for delivery over IP access networks (Figure 6). Telcos can use this technology in place of MPEG-2 to improve quality and lower video delivery bandwidth requirements, allowing their xDSL networks to provide new video services. These video services can help increase subscriber "uptake" and generate additional income from a broadband network. Envivio IPTV solutions:

- Transmit DVD-quality video at 1.5 Mbps bit rates
- Increase xDSL loop lengths, up to 18,000 feet
- Allow up to 4 simultaneous STBs per hub
- Let you deliver high-resolution HD channels

Advanced interactivity capabilities inside the stream format are part of the MPEG-4 standard and enable delivery of new interactive content without proprietary middleware. Envivio has powerful tools to create, customize, and manage interactive content.

Figure 6. H.264/AVC reduces IP video services deployment costs from MPEG-2 (Source: Envivio, Inc., 2004 based on Envivio pricing through March 31, 2004)



A Deployment Cost Scenario

Figure 6 compares IPTV upfront and per-subscriber deployment costs for MPEG-2 and H.264/AVC over an existing DSL infrastructure. Due to its newer technology and possible volume price-points with MPEG-2 equipment, headend costs are slightly higher for H.264/AVC equipment. Access network costs, however, are much higher when deploying MPEG-2. The cost of running fiber from the headend to remote DSLAMs, plus additional equipment to drive DSL signals beyond 8,000 feet, add significant up-front costs not incurred with H.264/AVC deployment. Amortized and direct per-subscriber costs are more favorable for H.264/AVC.

Even though headend costs are slightly higher for H.264/AVC, lower overall costs result in faster return-on-investment (ROI) for H.264/AVC. Based on a 25,000 subscriber base, 125 video channels, 5% VOD costs with 50% revenue from basic cable, ROI can be achieved in ten quarters of operation.[3]

Table 1 lists new deployment costs for H.264/AVC services based on Envivio, Inc. pricing through March 31, 2004.

Table 1. Up-front and Per-subscriber Costs for New Deployment Technology

Technology	Cost ($US)
Up-front Costs	
Headend (encoders, transcoders, rate shapers, video servers, core network)	1,348,000
Middleware (server license)	275,000
Access Network (DSLAMs, fiber plant)	1,100,000
Per-subscriber Costs	
Headend (amortized costs: video server, stream, core network)	20
Middleware (server license, client license, browser, MPEG-4 player, custom player)	70
Access Network (line cards, amortized repeaters)	125
CPE (ADSL Plug/Modem, STB, Install)	460

Intel® Processing Technologies

H.264/AVC is an evolutionary advance on H.263 and MPEG-4 SP and MPEG-4 Advanced Simple Profile (ASP). H.264/AVC is a highly efficient, technologically advanced software-based codec and requires greater processing capabilities beyond previous hardware used to generate MPEG-2 streams—as much as 8X demand for encoding and 4X demand for decoding. And, while MPEG-2 solutions are expensive hardware-based, proprietary systems, today's open-standards, Intel® Architecture-based platforms provide the processing capabilities that H.264/AVC needs to deliver DVD-quality digital video over DSL networks at low cost.

Intel Architecture Features for H.264/AVC

Table 2 lists key Intel Architecture features from which H.264/AVC benefits.

Intel Architecture Benefits for H.264/AVC

Intel Architecture-based STBs provide the time-to-market, flexibility, and performance for telcos to deploy H.264-based IPTV services.

- Flexible STB platform designs based on standard Intel Architecture building blocks provide the programmability and scalability needed to support software codecs for advanced compression, middleware, applications, and user interfaces.
- Intel Architecture-based designs are supported by a familiar software tools environment that can help accelerate the development and deployment of high-revenue services, such as video-on-demand and interactive TV, without the cost of re-engineering the hardware.
- Any potential changes or modifications required on the service in the future can be done through a "down-the-wire" software update to the STB.
- With high performance and headroom, Intel Architecture-based STBs can handle the H.264 decode workload, as well as other applications and services that telcos may choose to deploy.

Intel Architecture provides telcos the best platform for handling their current and future needs. Intel is a leading supplier of standards-based, high-performance, cost-competitive silicon for communications networks infrastructure equipment, including hardware for IPTV service deployment. Intel® Xeon™ processor-based encoders, hosted on datacenter servers and distributed intelligent networks, Intel Itanium® processor-based servers for database and security applications, and Intel network processors create high-performance engines for the services customers demand today, with headroom to scale to exciting new services emerging on the horizon.

Table 2. Key Intel® Architecture Features for H.264/AVC

Feature	Benefit
Intel® Xeon™ processor DP, Intel® Xeon™ processor MP, Intel® Pentium® 4 processor, Intel® motherboards	High-performance processors and motherboards designed and tuned for multi-threading and multi-tasking applications, including the intensive video encoding demands of H.264/AVC, and high-performance, cost-effective STBs for decoding
400 MHz and 800 MHz front side bus	Industry-leading processing performance for quick access to system memory and fast completion of processing tasks and encoding calculations
Large on-chip L2 and L3 cache	Retains more data closer to the CPU engine for fast completion of encoding calculations
Intel NetBurst® microarchitecture	High optimization of H.264/AVC prediction and encoding functions
Hyper-Threading Technology**	Boosts performance of encoding hardware platforms with fewer processors
Open-standards-based technologies	High-performance, cost-effective hardware platforms that reduce solution costs

H.264/MPEG-4 AVC: The IPTV Enabling Technology Standard

The need for an advanced video coding standard that evolves MPEG-2 and H.263 to the next level has been addressed over the last several years through a combined working group of the ITU-T and ISO/IEC organizations, who have previously produced the H.26x and MPEG-x standards, respectively. The new standard has emerged as H.264. It is also called MPEG-4 Part 10, or MPEG-4 Advanced Video Coding (AVC). The following table summarizes the development of these standards and their intended applications.

Video Coding Standards

Standard/Recommendation	Developer Organization	Applications
H.261, H.263, H.263+, H.263++	ITU-T	Video telephony, Video conferencing
MPEG-1, MPEG-4 SP/ASP	ISO/IEC JTC1	DVD, Video-on-demand, digital video broadcast via cable/satellite/DSL, video streaming for Internet and wireless
H.262/MPEG-2, H.264/MPEG-4 AVC	Joint Video Team (JVT) formed by ITU-T and ISO/IEC JTC1	Video-on-demand, digital video via cable/satellite/DSL, video streaming for Internet and wireless, IPTV

MPEG-2, a hardware-based technology, has been the industry-standard digital video broadcast codec for many years for high bit rate applications. MPEG-2 requires 2 Mbps of bandwidth, which is available over coaxial lines and satellite airwaves, to deliver broadcast-quality, jitter-free, digital video.

MPEG-4 Simple Profile (SP) and Advanced Simple Profile (ASP) were developed for streaming video over Internet connections. MPEG-4 offers a software method to compress and decompress video over a network that provides only a best-possible connection with a wide range of data rates. The result is not what viewers have come to expect from their televisions, but enough to offer interesting services and enhance the richness of the Internet experience.

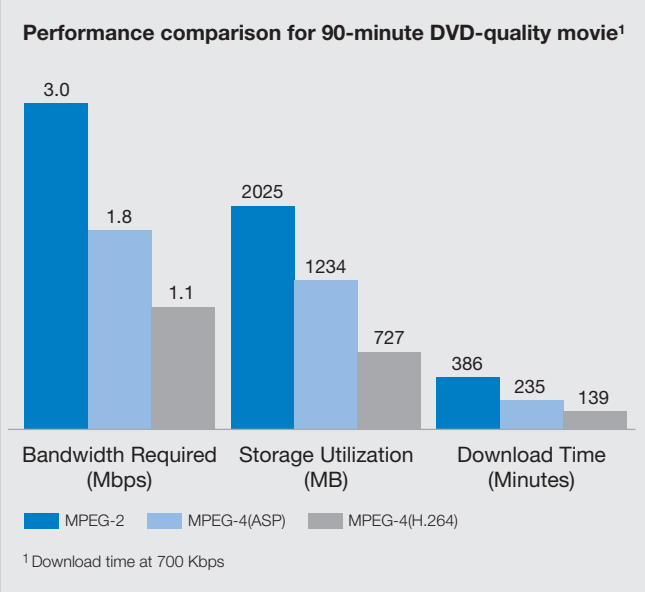
H.264/MPEG-4 AVC addresses the needs for greater compression, leading to lower data rates, while maintaining broadcast quality for video-on-demand (VOD) and high-definition television (HDTV) needs. H.264 meets the needs of both broadcast and the Internet by cutting the MPEG-2 bit rates in about half for digital video transmission-without a loss in video quality. This advance has followed the evolution of video compression science toward higher quality and lower bandwidth, and it opens new doors for service providers operating over the local copper loop infrastructure. Using H.264/MPEG-4 AVC and new H.264-enabling technology platforms for encoding, transport, and decoding, telcos and ISPs can boost their average revenue per user (ARPU) with exciting and compelling new video-on-demand, HDTV distribution, and interactive TV services. The age of IPTV over DSL has arrived.

H.264/AVC Benefits

H.264 is a breakthrough for video distribution over DSL. The new standard:

- Doubles compression efficiency, lowering bit rates to half of the MPEG-2 requirements for high-quality video and decreasing necessary storage capacity (see graph at right).
- Allows more content to be transmitted over existing infrastructures using its lower bit rates.
- Lowers transmission costs by sending the same information in half the time.
- Lowers deployment costs with new H.264/AVC technology platforms built on standards-based, non-proprietary processing hardware.
- Incorporates a Network Adaptation Layer that offers flexibility through transportability over packet and bit stream networks, allowing easy upgrades to existing MPEG-2-based delivery solutions.
- Maintains a high level of viewer experience in packet and wireless bit stream networks through error resilience.
- Uses a common set of technologies between mobile and IPTV: TCP/UDP streaming + H.264/AVC.

H.264/AVC benefits bandwidth demand, storage requirement, and download times



Summary and Conclusion

H.264/AVC helps enable telcos to boost their ARPU and retain their competitive position by offering IP video services, such as video-on-demand and IPTV, using their existing copper infrastructure and DSL technologies. H.264/AVC reduces the bandwidth requirements for delivering broadcast- and DVD-quality video streams to well within the limits of a 1.5 Mbps DSL loop. Reduced bandwidth demand means a larger IP video services TAM for telcos, reduced costs compared to MPEG-2-based video service deployment, and higher density of services on their current infrastructure.

Envivio offers H.264/AVC solutions to telcos for deploying new IPTV services, including tools for encoding, decoding, video serving, system management, and interactive content development. Envivio uses Intel® Architecture-based hardware in their solutions to help ensure the high-quality video streams that customers expect, but for lower cost compared to proprietary systems.

H.264/AVC helps create new opportunities for telcos ready to invest in this new video compression standard, and Envivio and Intel provide the solutions necessary to let telcos deploy new IPTV services.

1 MRG, Inc., 2003

2 DSL Forum, 2003

3 Envivio, Inc., 2004 (see http://www.envivio.com/markets/roimodel/index.html)

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