Cisco IPTV Video Headend

Defining a Superior Video Experience

Introduction

To meet the evolving demands of today's media consumers, service providers must transform from traditional providers of access-based services to all-inclusive "experience providers." That means being able to offer voice, video, data, and mobility, or "quad-play" services, anywhere, anytime. For conventional wireline carriers embarking on this journey, IPTV is one of the most important aspects of this transformation.

Today's consumers expect stunning picture quality and excellent reliability, as well as a variety of advanced video services, which challenge service providers to deliver new capabilities while fully utilizing available bandwidth in the IP network. To deliver a compelling differentiated video experience, an IPTV offering must encompass effective solutions to:

- *Define* the video experience: First, service providers have to define the experience, which not only effectively competes with existing offerings, but also clearly differentiates the experience from competitors' offers. Carriers need solutions for acquiring, processing, encoding, and managing video content efficiently, as well as broad expertise to help ensure that analog, digital, and IP technologies closely interoperate to deliver a best-in-class video experience. Defining video experience encompasses many dimensions, for example, standard and high-definition content; choice of compression techniques; and a variety of next-generation video services such as interactivity, video-on-demand (VoD), network PVR (nPVR), and targeted ad insertion.

  The Scientific Atlanta Video Headend and Cisco® Content Delivery System (CDS) are the key solutions that enable service providers to define the video experience.

- *Preserve* the video experience: The next step is to preserve the video experience as the video traffic is transported across an IP infrastructure. Service providers need an intelligent, video-aware, carrier-class IP network that can effectively preserve the video content and the experience all the way from the headend to the end-consumer device.

  The Cisco Layer 3-based, content-aware, intelligent IP Next-Generation Network (NGN) ServiceFlex architecture offers superior video-to-network linkages such as Visual Quality Experience (VQE) and Video Admission Control to preserve the video experience. Additionally, carriers can take advantage of Cisco IP "anycast" support for quick failover support between encoder and streamer outputs for 1:1 network path redundancy, which with encoder redundancy in the headend, helps ensure highly available service and better quality of experience.

- *Realize* the video experience: An outstanding video experience requires robust solutions in the customer home to decrypt, decode, share, and display the content the way it was intended. The home networks and consumer devices are the gateway not only for video content, but also to realize the delivery of integrated media experiences. Scientific Atlanta and Linksys® provide innovative products and technologies to realize the growing expectations of media consumers.

While each aspect of an overall IPTV solution plays an important role, the true core in defining an IPTV experience is the Scientific Atlanta video headend and Cisco CDS. The headend receives the content from multiple sources and transforms it into a seamless mix of national and local television programs, advertisements, and interactive video services. The choices made in the headend on how to acquire, process, encode, and manage video ultimately define the quality of the subscriber experience—and in many ways, the success of the IPTV offering.

Building a successful video headend is no small task, especially for wireline carriers embarking on video services for the first time. Video headends encompass a broad range of heterogeneous technologies. For example, different IPTV channels may be encoded in different versions of MPEG. Depending on how encoding is implemented in the newest version of MPEG-4 part 10, also known as the Advanced Video Codec (AVC) or ITU H.264 standard, the end results subscribers experience may be sharply different.

When it comes to selection of the right components for the headend and helping ensure that they seamlessly integrate to provide a high-quality video experience, service providers do not have to go it alone. They can deploy a complete, IPTV-optimized headend from Cisco and Scientific Atlanta. Scientific Atlanta, now a Cisco company, can offer service providers vast video expertise and more than 55 years of experience creating, integrating, and deploying successful video headend technologies. Unlike competitors who offer point solutions for the video headend, Cisco and Scientific Atlanta can bring every aspect of the headend together into a single, comprehensive solution.

Scientific Atlanta Video Headend Differentiators

To provide a successful IPTV offering, the Scientific Atlanta video headend effectively addresses key requirements that clearly differentiate it from the competitors:

- Award-winning* MPEG-4 AVC encoders with better video quality at lower bit rates: IPTV access networks, especially those relying on digital subscriber line (DSL) connections to the customer home, may have less available bandwidth, and carriers must employ advanced video compression solutions. A successful IPTV deployment has to deliver both: excellent video quality, which is a key aspect of the video experience, and bandwidth efficiency needed for DSL connectivity. Scientific Atlanta encoders deliver:
  - Better video quality using single-slice processing
  - Higher bandwidth efficiency using PreSight*Plus* algorithms
  - Better video performance and flexibility with extensive MPEG-4 AVC tool set implementation
- Superior scalability and flexibility: A video headend is a significant financial investment, so most carriers choose to build fully redundant headend architecture to serve national programming to the entire subscriber base. Scientific Atlanta offers headends that are supremely scalable and capable of supporting millions of subscribers. These headends are also flexible enough to easily integrate with new applications and features over time (such as VoD, HD content, and personalized ad insertion) without requiring a comprehensive upgrade.

* Model D9054™ has won an International CES Innovations 2007 Design and Engineering Award

- Carrier-class reliability: Since an IPTV infrastructure is built around a redundant super headend, carriers must minimize the system downtime. Scientific Atlanta offers carriers an option to deploy IPTV headend with "five nines" (99.999%) of uptime, equivalent to just five minutes of downtime per year. This level of reliability requires an additional layer of protection, such as steerable satellite dishes.
- Proven headend and middleware integration: Cisco integrates with leading providers of middleware and helps ensure that the combined solutions have been tested and proven to fully integrate with the headend, which is one of the two touchpoints for middleware (the set-top box is the second one).
- Superior manageability: The Scientific Atlanta's video headend is highly manageable and provides carriers with tools to control many components of the video network—including many third-party products—from a single screen. Also, many video hub locations do not have onsite staff and must be fully automated and remotely managed.

A Hierarchy of IPTV Headends

Scientific Atlanta designs, builds, and integrates three types of IPTV headends to meet national, regional, and local content distribution requirements:

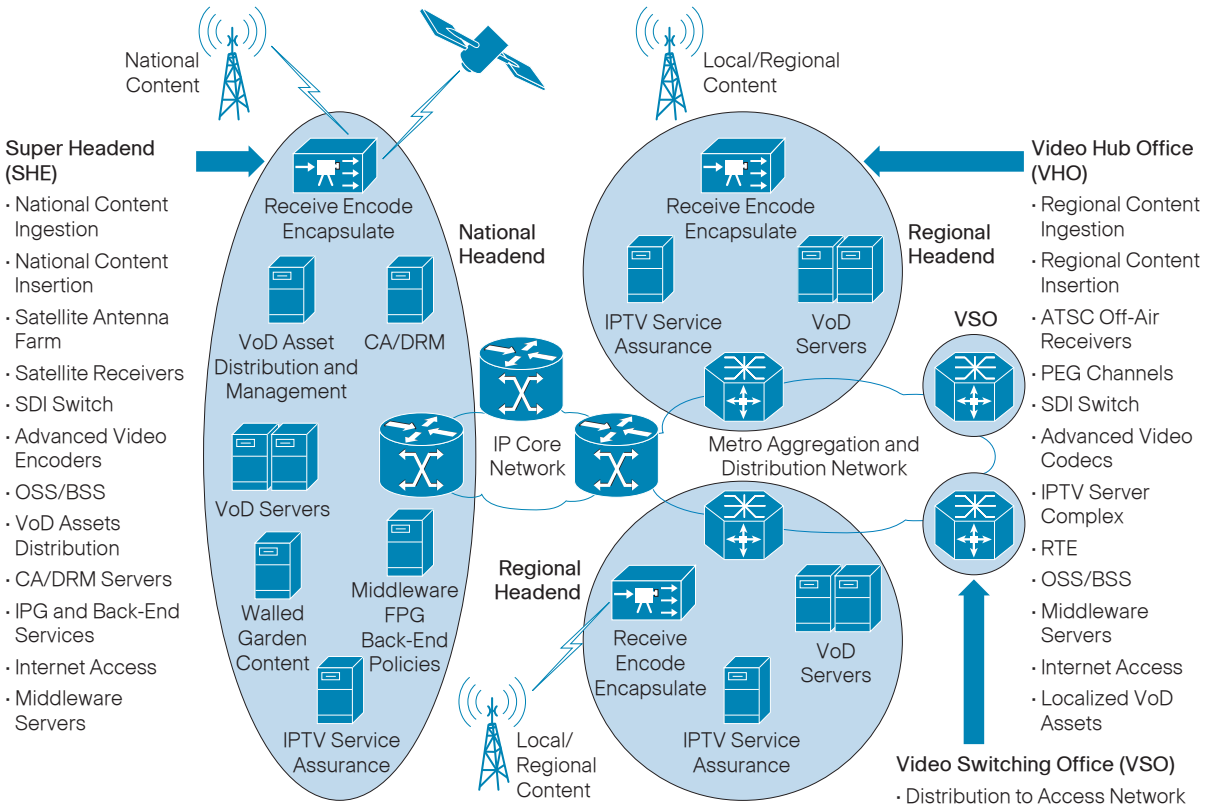
1. The Super Headend (SHE) ingests content on the national level and offers the largest coverage with greatest functionality. The highly reliable SHE aggregates live national content, processes it, encodes the content in MPEG-4/AVC (H.264), and distributes it through an IP core network to VHOs.
2. The Video Hub Office (VHO) is where regional and local content as well as on-demand services get integrated and aggregated with the national content. The typical VHO serves a metropolitan area of between 100,000 to 500,000 homes.
3.. The Video Switching Office (VSO) maps IPTV streams to the access network for distribution to consumers' homes.

By using different headends for national, regional, and local service, carriers can distribute a wide variety of customized and localized content complementing the national television program (Figure 1).

Headend Building Blocks

The IPTV headend encompasses solutions to acquire, process, encode, and manage video content. However, each of these areas presents unique challenges that must be addressed to create the high-quality video output that subscribers demand. Scientific Atlanta has been the industry leader in headend technologies for decades, and can deliver the combination of technologies and experience necessary to meet these demands.

Figure 1. SHE—VHO—VSO Hierarchy



Scientific Atlanta can provide in-house engineering expertise across the full spectrum of video headend technologies to deliver a comprehensive, customized solution that is optimized for a carrier's unique IPTV offering. With more than 1000 digital headends and more than 10,000 uplink channels deployed worldwide, Scientific Atlanta provides proven and comprehensive headend solutions.

Scientific Atlanta provides modular headends that give service providers the flexibility to easily add new services and capacity as the IPTV offering evolves.

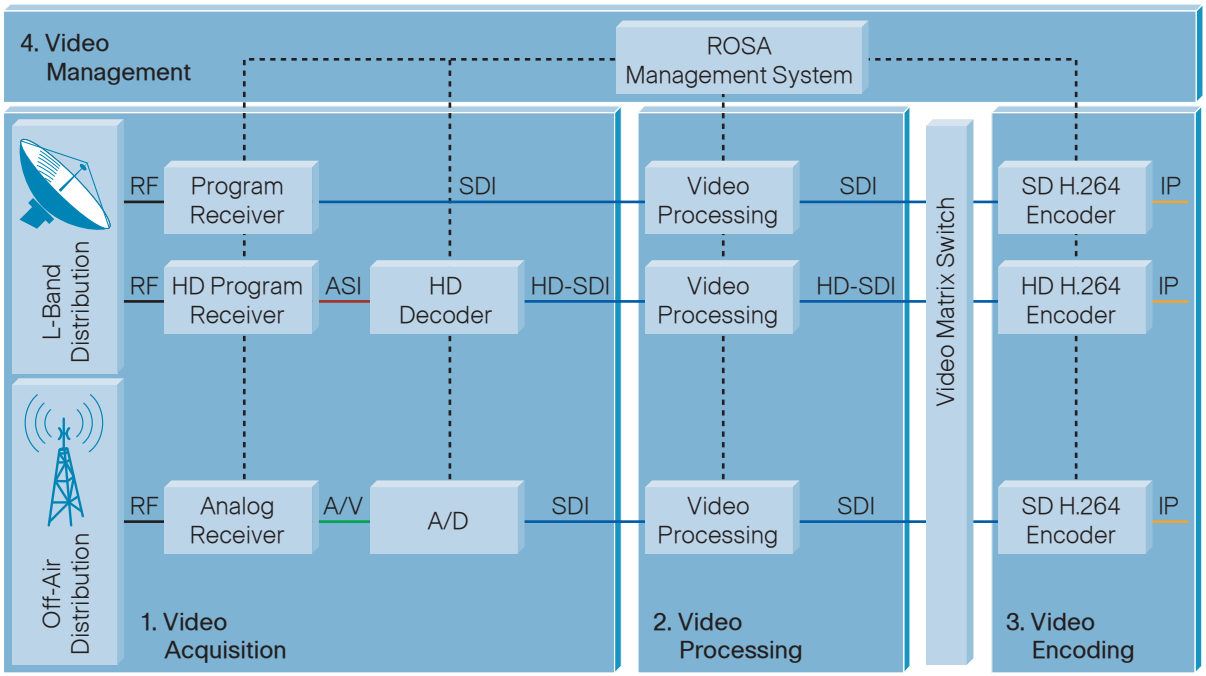
Scientific Atlanta headend solution includes four major building blocks (Figure 2):

1. Video Acquisition
2. Video Processing
3. Video Encoding
4. Video Management

1. Video Acquisition

IPTV service providers acquire television programming from many different sources. Each content provider can contribute that programming over a variety of resources, including satellite (analog FM, digital QPSK), off-air (analog AM, digital 8VSB/COFDM), and fiber (E3, DS3, ASI, SDI), and may use a variety of formats (digital MPEG-2, analog A/V, digital SDI) and encryption protocols. Decrypting, converting, and multiplexing (muxing) this content into a single national or regional video service is a complex challenge, requiring many different components to work together. Since every service provider offers its own menu of channels and services, with each requiring a unique mix of technologies, the video acquisition component of the headend must be built from the ground up as a customized solution.

Figure 2. IPTV Headend Building Blocks



Video acquisition is a most customized part of the headend and requires intelligent design with many tradeoffs (redundancy options, muxing capabilities, dish implementation, etc.). The goal is to collect and convert received video from a wide range of sources, including satellite, off-air, fiber, and other digital and analog sources using a wide range of devices, including: C-band and Ku-band satellite receivers, as well as off-air receivers into a serial digital interface (SDI).

However, the various components of this customized solution draw on vastly different areas of engineering expertise, making it difficult to offer a complete, integrated solution. Scientific Atlanta is the top-tier video provider with engineering expertise that spans all components of the video headend acquisition, and has proven experience integrating these disparate technologies into highly effective, customized headend acquisition solutions. The acquisition segment is designed with appropriate redundancy and backup/failover capabilities needed to satisfy the service provider's uptime goals.

Video Acquisition Product Portfolio

The Scientific Atlanta Content Acquisition segment consists of:

- Satellite Receive System: Satellite antennas to receive the customer-specified programming channels with required redundancy. If the antennas are outside of SHE, a layer of fiber optic provides transport of the L-Band streams to the SHE location. Steerable (motorized) antennas or multifeed antennas are used in the design to provide failover protection in case of a primary LNB failure or as a full antenna replacement should a primary antenna become damaged. Steerable antennas are also used for occasional services such as live special events.
- Off-Air Receive System: The off-air channels are received by Very High-Frequency ("VHF") and Ultra High-Frequency ("UHF") antennas. Then the content is filtered and extended via individual RF fiber or coaxial lines to the IPTV headend. Some off-air channels may also be received via a terrestrial fiber circuit for redundancy or if off-air reception is not available due to poor signal quality or other factors.
- Satellite Receivers and IRDs: For the Standard Definition (SD) content received in digital format these receivers demodulate and decode MPEG-2 audio/video into a single program stream digital output that is either a Serial Digital Interface (SDI) or Analog Interface. An analog-to-digital (A/D) converter is used to digitize the audio/video signal to SDI. For High-Definition (HD) content, the receivers demodulate the stream and provide an MPEG-2 Asynchronous Serial Interface (ASI) to an external HD decoder. The HD decoder provides a High-Definition Serial Digital Interface (HD-SDI). The SDI and HD-SDI streams are then processed and routed prior to being encoded.

  The content that is delivered in an analog format is converted to digital SDI using an analog-to-digital (A/D) converter prior to being routed to an encoder.

The Scientific Atlanta video acquisition products and solutions include:

- Titan MKII: The receiver for C-band antennas provides outstanding picture quality at a minimum cost and size.
- Atlas MKII: The receiver for C-band antennas is a compact, highly reliable, and easily manageable C-OFDM demodulator to DVB-ASI output. It is compliant with the DVB-T standard and can be used in DVB-T, cable TV, and broadband applications.
- Neon Rx: The adapter for Ku-band antennas carries MPEG-2 Transport Streams (MPEG-2 TS) over telecom networks. It accepts an E3 or DS3 signal and provides an ASI-compliant transport stream. This manageable adapter is fully compliant with ITU-T telecommunication standards to guarantee interoperability with existing equipment.
- Indus MKII: The descrambler descrambles selected programs in a transport stream to provide a 'clear' MPEG-2 TS digital signal output compliant with the DVB ASI specification. This flexible module is compatible with DVB standards such as the Common Interface for Conditional Access applications and ASI for interoperability.

- PowerVu D98xx Integrated Receiver/Decoder (IRD): With this family of IRD solutions, carriers can deploy effective, IPTV-optimized video receiver/decoder capabilities for any mix of video formats in a single, compact solution.

2. Video Processing

As video signals are acquired, the headend must process each signal for distribution. In the past, this process was relatively straightforward, as all subscribers viewed content on a single type of television with a single video format and aspect ratio. For the most part, video processing primarily involved helping ensure that local programming was effectively knit together with national video feeds. Today, the situation is much more complex. Carriers must process video to account for:

- Multiple viewing devices: Today's subscribers may be viewing a program on a midsize standard-definition (SD) television, a 100-inch HDTV, a three-inch screen on a handheld device, or anything in between. To effectively serve all subscribers across all devices, transrating tools must be used to deliver the same video in multiple resolutions.
- Local and regional ad insertion: IPTV services are switched to each subscriber's home allowing carriers to know what each viewer is watching and giving carriers the opportunity to deliver much more targeted, personalized, and profitable advertising. Carriers need technologies to provide clean digital ad insertions on a per-region or even per-subscriber basis, with no visual artifacts or changes in picture quality.

- Trick-play functionality: To provide a more compelling, convenient video experience, many carriers are deploying VoD and nPVR services that allow subscribers to pause, fast forward, and rewind television programs. However, these "trick-play" capabilities require carriers to deliver not just the normal broadcast stream of a program, but also rewind and fast-forward streams, often at multiple speeds.
- Audio/Video adjustments—To provide equalized audio and video levels across all channels, some channels may need certain level adjustments to provide a consistent experience when users tune between channels.

The Scientific Atlanta Video Processing Solution

Scientific Atlanta addresses these challenges with highly effective solutions. One of the key solutions is the Digital Content Manager (DCM) Model D9900. The DCM Model D9900 is a compact MPEG processing platform that can process thousands of video streams simultaneously, including DVB Simulcrypt scrambling and digital program insertion (DPI). The DCM provides essential functionality to support next-generation video applications, including HDTV and on-demand digital services, local program, and advertising insertion. The DCM is managed via an intuitive, HTML- and Java-based interface. The DCM Model D9900 provides (Figure 3):

Figure 3. Digital Content Manager Model D9900

- Industry-leading processing capabilities: grooming and remultiplexing: Constitutes the first steps in MPEG processing. The DCM also supports extensive transport stream and program analysis including program-level bit rate measurements on both incoming and outgoing streams to allow the operator to easily configure the content into logical outgoing program groups.
- Advanced processing capabilities: transrating, statistical multiplexing, and rate limiting: Using intelliRate Plus advanced transrating technology and algorithms, carriers can accept video from studios at any bit rate and deliver optimized video streams for any SD, HD, or mobile device, while conserving bandwidth.
- State-of-the-art digital program and ad insertion: The DCM Model D9900 provides the capacity and scalability to support thousands of national and regional ad placements, as well as smooth handling of audio and Teletext insertion.

- Support for a wide range of delivery mechanisms: Carriers can deliver the full mix of broadcast video, VoD, and switched video applications that subscribers demand. The DCM Model D9900 can even offer bulk encryption capabilities to streamline VoD video processing.
- Unmatched performance and efficiency: The DCM Model D9900 employs state-of-the-art microprocessors and video processing algorithms to provide the highest-capacity transrating and ad splicing in the industry. The solution can currently deliver 1,400 SD and 340 HD video streams, and 700 SD and 160 HD ad splices simultaneously with a single 2 Rack Unit (RU) platform. Other solutions currently require as many as 78 RUs to deliver the same performance.
- Exceptional scalability and flexibility: The DCM Model D9900 provides native support for both SD and HD muxing and splicing, allowing carriers to take an evolutionary approach to adding new HD services. The solution's modular design allows carriers to increase functionality and expand services simply by swapping cards, instead of requiring a comprehensive upgrade.

3. Video Encoding

The core of the video headend—and the true differentiator in video picture quality—is the video encoding solution that shapes the video experience for display on the subscriber's screen. Even when carriers deploy excellent video acquisition, processing, and management solutions, the choices they make in video encoders ultimately determine the quality of the IPTV offering. While carriers are challenged to deliver the best possible picture quality, they must also do so using minimal bandwidth, and many IPTV providers are ready to deploy the latest Advance Video Codecs (AVC). MPEG-4/AVC part 10 (H.264) video encoding meets these high-quality requirements using lower bandwidth.

MPEG-4/AVC allows carriers to cut the amount of bandwidth per stream on average in half when compared with MPEG-2 encoding. However, to accomplish this significantly lower bandwidth without compromising video quality, MPEG-4 encoding algorithms must be implemented optimally, which is not a trivial task. MPEG-4/AVC encoding is an extremely complex process, encompassing many more variables and a much larger set of techniques than MPEG-2 encoding.

Video Encoding Product Portfolio

Scientific Atlanta provides state-of-the-art SD and HD MPEG-4 video encoding solutions for IPTV providers and is an industry leader in video encoding. The ROSA Element Manager and other third-party control system applications provide robust configuration, monitoring, and failover mechanisms for the encoders in addition to the Web administrator interface and front panel operator console. The encoder products include:

- D9054 MPEG-4/AVC HD Encoder (Figure 4): This encoder accepts a High-Definition (HD) SDI signal and encodes it in real time to the MPEG-4 part 10 in 4:2:0 Main or High-Profile Level 4 standard. The output of the encoder is UDP-IP multicast or unicast in a single program MPEG-2 TS (SPTS). The MPEG-4 encoded video is also available on an ASI transport, and both the IP and ASI ports can stream simultaneously.

The HD Encoder supports two stereo pairs in multiple audio formats:

- MPEG-1 Layer II audio
- Dolby Digital (AC-3) 2.0 audio
- HE AAC and LC-AAC audio with a broad range of bit rates
- Pass-through for externally encoded Dolby 5.1 or HC/LC-AAC 5.1 audio

The encoder supports embedded audio and embedded closed captions transferred in the HD-SDI for efficient routing and simpler back-up system designs. The encoder can also be equipped with an optional integrated picture-in-picture (PIP) encoder for scaled video applications. To provide efficient management, the encoder is designed to support an on-board HTML (Web) interface, front panel control, and SNMP protocol for ROSA Network Management and other third-party control system applications.

Figure 4. Advanced Compression Encoder, Model D9054 HDTV

- D9034 MPEG-4/AVC SD or MPEG-2 SD Encoder: This encoder accepts a Standard Definition (SD) analog or SDI signal and encodes it in real time to the MPEG-4 part 10 in 4:2:0 Main Profile Level 3 standards. The output of the encoder is UDP-IP multicast or unicast in a single program MPEG-2 TS. The MPEG-4 encoded video is also available on an ASI transport, and both the IP and ASI ports can stream simultaneously. The Encoder supports up to four stereo pairs in multiple audio formats, identical to the D9054 HD encoder (Figure 5).

  The encoder also supports an optional integrated picture-in-picture (PIP) encoder for scaled video applications. Also, the encoder can optionally support simultaneous streaming of MPEG-4, MPEG-2, and PIP services. Complete configuration and control of the encoder are available through an on-board HTML (Web) interface offered through the dedicated management IP data port, or via the front panel operator console. To provide efficient management, the encoder also supports SNMP for ROSA Network Management System and other third-party control system applications.

Figure 5. AVC Encoder, Model D9034 SD

Scientific Atlanta MPEG-4/AVC video encoders employ Advanced Compression Encoding (ACE) technology and the Scientific Atlanta PreSightPlus architecture to deliver superior picture quality and excellent bandwidth efficiency. These solutions provide:

- Superior encoding and compression: The Scientific Atlanta PreSight*Plus* preprocessing architecture allows carriers to perform multiple pre-processing steps simultaneously to optimize the encoding process. For example, PreSight*Plus* can look ahead to future frames to determine which aspects of the picture will change, and optimize the video encoding based on this information. PreSightPlus also provides "multi-pass" capabilities, allowing carriers to compress a video stream once, review the stream to determine if the compression is optimal, and re-compress if necessary.
- Extensive MPEG-4 toolset implementation: MPEG-4 encoding is extremely complex, and must account for wide variation in motion, luminance, and color in every video stream. Scientific Atlanta encoders employ a comprehensive MPEG-4 toolset, allowing carriers to deliver a better picture at a lower bit rate by using a CABAC (Context-adaptive arithmetic coding) algorithm with continuously updated statistical models and resets after each slice; as well as subpel search on all block types (16x16, 16x8, 8x16, 8x8, etc). It also implements bipred search on all block types with direct search on every Macro Block (MB) and large motion vector search range (288x216).
- "Single-slice" processing: To provide a high-fidelity picture, especially in HD, encoders must process video to account for subtle changes in light and movement through each moment of a program. Other video encoding solutions segment an HD picture into up to six "slices," and encode HD video based on each slice—representing just one sixth of the full-screen picture. This technique can produce suboptimal quality, since different slices of the picture may contain different colors, luminance, and movement. Scientific Atlanta HD and SD encoding solutions perform single-slice, full-picture encoding to deliver clean, stunning picture quality at extremely efficient bit rates.

4. Video Management

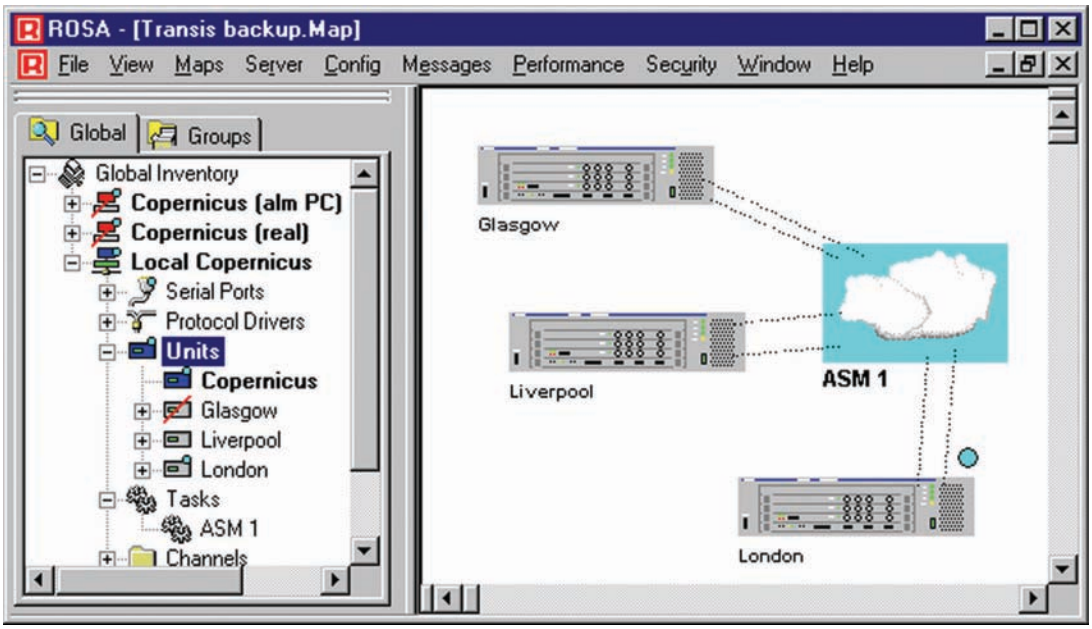
With all of the various technologies and applications operating within the video headend, carriers need solutions to manage the entire headend as a single entity, from a single interface. Since many video hubs do not have onsite staff, carriers must be able to manage all solutions across the service network—including third-party devices—remotely. Finally, building and operating a video headend effectively require significant in-house, rich-media expertise.

Scientific Atlanta Rosa Network Management System

The Scientific Atlanta ROSA Network Management System (NMS) monitors, accesses, configures and controls network devices that are incorporated in the headend and the ROSA Element Manager (EM) monitors, controls, configures, automatically backs up failed equipment, alerts the operator of the failure, performs automated tasks, and translates proprietary protocols to SNMP for the overall network manager.

The ROSA NMS platform lets service providers remotely manage all active Scientific Atlanta and most third-party acquisition, processing, and encoding devices in the network from a single screen, using a powerful GUI. The platform also includes high-availability tools to help ensure smooth failover to a backup headend in the event of a failure (Figure 6).

Figure 6. ROSA Network Management System



The ROSA NMS provides:

- Full, automatic redundancy with autonomous management of backup and failover routines with routing control of each video stream
- Performance data collection and recording from all network elements as well as performance and trending reports on network availability and performance
- Scalability to grow with the IPTV offering, including support for more than 725 devices through SNMP and proprietary protocols
- A design based on open standards with options to control video testing and routing of video feedback to the video operations center

With over 1500 installations worldwide, ROSA has proven to provide state-of-the-art system manageability in many diverse deployments on the global scale.

Defining an Exceptional Video Experience: Scientific Atlanta IPTV Headend Solution

Today's service providers are striving to deliver a high-quality differentiated video experience to their subscribers. Creating that experience begins in the video headend. However, each headend represents a unique mix of technologies and applications, and Cisco and Scientific Atlanta can integrate industry-leading technology, broad-based engineering expertise, and decades of video experience into a single, comprehensive solution.

Scientific Atlanta headends provide best-in-class video quality, superior bandwidth efficiency, and industry-leading flexibility in a modular, scalable design. With Scientific Atlanta's carrier-class reliability and comprehensive and widely deployed management system, wireline carriers can enter the world of digital video services with confidence.

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