

## Art and Science: Video Processing and Quality Measurement

By Monta Monaco Hernon

As the number of American households with big screen TV sets grows, so does the demand for more high definition (HD) programming. At the same time, the bigger and better the picture, the more clearly imperfections can be seen. In addition, the availability of other HD sources is contributing to consumer demand for both quantity and quality.

"MSOs are getting competition from satellite (companies) who are pushing the video quality angle, and new competitors (like telco TV (and) Blu-ray, where consumers are seeing much clearer pictures," said Nabil Kanaan, director, product marketing, for RGB Networks.

The good news is that operators have a number of options to

help meet this demand, ranging from the longer-term MPEG-4 to alternatives being delivered today, including switched digital video (SDV) and analog reclamation.

"As an industry, we are in a solid position for the foreseeable future to manage bandwidth effectively and roll out HD," said Gregg Grigaitis, vice president, advanced technology, Suddenlink Communications.

There also is a video processing option to help operators get more bang for the bandwidth while still utilizing MPEG-2 technology. But there has been some question as to whether this muxing magic degrades quality.

### MULTIPLEXING MOJO

While two HD streams at 19 Mbps are generally what fits on one 38.8 Mbps 256-QAM (quadrature amplitude modulation) channel, several vendors are offering solutions that combine three HD streams at lower bit rates in the same bandwidth.

They utilize either closed-loop or open-loop statistical multiplexing. With closed-loop statistical multiplexing, the encoders compress the content using feedback control from the statistical multiplexer. The multiplexer

is typically co-located with the encoders, although remote techniques are possible, said Matthew Goldman, vice president of technology for compression systems, Tandberg Television.

"With closed-loop, the (video stream) hasn't been encoded yet. On a frame-by-frame basis, the (statistical multiplexer) tells each encoder how many (bits) it can use," Goldman said.

Harmonic Senior Director Product Marketing J.C. Morizur said with closed-loop statistical multiplexing, de-encoding and then re-encoding actually occurs. As a result, the picture quality can be improved, by reducing noise or removing macroblocking, for example.

Using today's IP networks, it is possible to set up a virtual situation where the encoders and statistical multiplexers can be in different geographical locations. "They participate in the same closed-loop statistical multiplexing pool over an IP network," Morizur said.

Alternatively, with the open-loop method, the video stream is already encoded. Particular programs are selected from multi-program transport streams. "(You are) looking real-time for the

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### VOD VARIABLES

Video on demand (VOD) traditionally is encoded at a constant bit rate (CBR), which allows for a maximum of 10 SD streams or two HD streams per QAM channel.

By using a variable bit rate (VBR), 50 percent more streams can be stat-muxed together in the same QAM channel, said Marc Tayer, Imagine Communications, senior vice president, marketing and business development.

"Unlike broadcast, where it is typically VBR anyway, VOD is CBR, so there is even more room for improvement because CBR is so bandwidth inefficient," Tayer said.

Nabil Kanaan, director, product marketing, RGB Networks, called the waste baked into content with CBR encoding "low-hanging fruit."

"A simple example is when you fade to black," Kanaan said. "The low motion dark scenes translate to pretty low payload bits being used to encode that content."

The bandwidth saved can be used for any service.

"Operators will be able to get more VOD content per QAM and dedicate [fewer] QAMs to VOD and maybe more to HD," said Marty Stein, senior marketing director, Motorola IP video solutions group.



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## QUALITY MONITORING

When a stream is generated, it has a long road to travel before the content reaches the consumer.

"As the cable operators move entire infrastructures to digital and are running all of their services through massive IP networks, problems have become more difficult to find and solve," said Eric Conley, CEO, Mixed Signals.

"Any impairment, especially packet loss, is viewable by the customer," said Jim Welch, IneoQuest senior consulting engineer. "Even a single packet loss is usually represented by a glitch or macroblock."

Welch recommended monitoring at the egress point of key locations, including the headend, as well as the input and output of every hub site.

"(You) want to use a divide-and-conquer strategy," he said. "Monitor what is coming in and what is going out. If it is good going in and impaired going out, the problem is in that location." It's also important to be able to look inside the streams to be able to determine that each is not only making its way from point A to point B in a timely manner, but also that the content being delivered looks and sounds "great," Conley said.

"What we can do is enough decoding of video in a scalable way to know where on the screen the problems are occurring, how they are manifesting, and how long they will be there," Conley said.

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bandwidth needs of the channels and programs you want to pass on," Kanaan said.

"If one channel has low demand and one has high demand at a certain time, they can give more of the bandwidth instantly to the (high demand) channel and rob a little bit from the channel that doesn't need it," said Marty Stein, senior marketing director, Motorola IP video solutions group.

The secondary method is to use an algorithm to determine the low frequency areas of a pic-

ture that the human eye generally doesn't detect and throw them away, Stein said.

"(The equipment) can't tell that a crowd is cheering, but can see a spike in bandwidth as being transmitted from ESPN," Stein said. "It can delay some of the stream by milliseconds to make it line up with a low demand scene, or if all else fails, it can then go in and decide from each stream what data they can actually drop that will have the least impact on the viewer."

## MIX AND MUX

Part of the science is choosing which channels to multiplex. News programs, for example, don't have much high frequency information, but sports do.

"There are intelligent ways to do three to one," said Doug Jones, chief cable architect, BigBand Networks. "We provide tools which analyze the individual video streams and make recommendations about which channels to put together in a QAM."

Measuring quality is part of the challenge. As Imagine Communications reduces the bit rate of the stream, it measures the quality against the source for every section of every frame, based on a scale 1 to 100.

"If we have a number that is roughly in the 96 range, even expert viewers very rarely tell the difference from the compressed source," said Marc Tayer, Imagine Communications, senior vice president, marketing and business development.

## STUFFED QAM

Within a 38.8 Mbps QAM channel, at any given time, there is a certain amount of stuffing to fill in bandwidth not currently being used.

"One of the ways to track the quality of a multiplex stream is keeping track of the amount of stuffing," said Jim Welch, IneoQuest senior consulting engineer. "If the stuffing drops to zero for a period of time, you can bet there is over-subscribing

of the 38.8 megabit stream, and that means quality will suffer." (For more on quality measurement, see the sidebar at left.)

In the end, quality might be a judgment call for the operators.

"Some service providers, MSOs, are happy with three-into-one HD quality, while other operators are not happy or believe it is not acceptable," Goldman said. The constraints of MPEG-2 video technology, however, and not the solutions on the market are to blame for most of the quality issues, he added.

Suddenlink is investigating the option of three-to-one in a laboratory setting and doing side-by-side comparisons of the end result to the original source, using employees in double blind studies.

"Nothing will go into the field until we have conclusively, with the team back here, certified that there is not visual difference to this content that would be discernable to our customers," Grigaitis said, noting, however, that his company is not yet up against the ceiling regarding bandwidth.

Bresnan Communications uses services from Comcast Media Center, which does use three-to-one technology. But internally, Bresnan is looking at other tools, including recovering analog and all-digital.

"To do it right would be too expensive," Pragash Pillai, VP strategic engineering, said.

—Monta Monaco Hernon

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### BigBand Networks ([www.bigbandnet.com](http://www.bigbandnet.com))

Product	Application	Key Features
<b>Broadband Multimedia-Service Router, BMR 1200</b>	Platform for network delivery of video services	Bandwidth management functionality speeds delivery of high value video services; carrier class with “five nines” availability; support for DTV transition, digital simulcast, digital TV management, digital ad insertion, HDTV and SDV; converges rich media processing and IP transport for operational efficiencies; field proven with 200+ customers worldwide
<b>Media Services Platform, MSP2000</b>	Network-based delivery platform	Seamless transition from broadcast to personalized video; harness existing infrastructure for new revenue opportunities; carrier-grade platform with high availability and redundancy; reliable delivery of IPTV, personalized video and linear addressable advertising; support for digital advertising with splicing into encrypted streams

### Cisco Systems ([www.cisco.com](http://www.cisco.com))

Product	Application	Key Features
<b>Digital Content Manager (DCM) Model D9900</b>	MPEG processing platform	Supports high numbers of video streams; accommodates bandwidth management of several encoder pools using IP-based closed loop stat-muxing; supports up to 8 Gbps of input and output; 2RU chassis with hot swappable and redundant power supplies; can be configured with up to four I/O cards, with each having either 10 ASI ports or four GigE ports; optional built-in DVB scrambler.
<b>Advanced Program Receiver (D9854)</b>	Receiver and decoder	Can acquire multiple signals (both SD and HD), descramble them, and monitor them at the reception site; supports multiple CA systems and DVB-S2; support for third-party CA systems, as well as Cisco’s PowerVu.
<b>Advanced Receiver Transcoder (D9858)</b>	Transcoder	Provides transcoding capabilities to support the efficient satellite delivery of HD content to headends using MPEG-4 video compression and DVB-S/S-2 technology; transcodes MPEG-4 HD content into an MPEG-2 HD or SD stream to enable legacy MPEG-2 set-tops to receive the HD programming.

### Harmonic ([www.harmonicinc.com](http://www.harmonicinc.com))

Product	Application	Key Features
<b>DiviTrackIP</b>	Distributed statistical multiplexing solution	Connects encoders and multiplexers via a switched IP network, allowing flexible reconfiguration of multiplexer input; all-IP structure eliminates distance constraints associated with ASI routing and allows network devices to be located in different sites; designed to enable the most advanced, efficient statistical multiplexing
<b>ProStream 1000</b>	Stream processing platform	Allows multiplexing, scrambling, and advanced processing of MPEG streams in a compact and flexible 1-RU design, simplifying network architecture while offering a highly scalable digital turn-around (DTA) solution
<b>ProStream 1000 with integrated DiviTrackMX</b>	Stream processing platform with statistical multiplexing	Designed to offer flexibility and scalability by providing re-encoding, multiplexing and scrambling within a compact 1-RU platform; up to 64 VBR or CBR services are re-encoded in multiple closed-loop DiviTrackMX pools; intended for DTA systems; designed to provide “headend-in-a-box” capability
<b>DiviTrackXE</b>	HD/SD stat-mux	Designed to provide closed-loop HD and SD statistical multiplexing for ASI-based systems

### Imagine Communications ([www.imaginecommunications.com](http://www.imaginecommunications.com))

Product	Application	Key Features
<b>ICE Broadcast System</b>	Advanced video processing for digital broadcast	IP/GigE inputs and outputs; high availability clustering technology with standards-based hardware and software components; incorporates ICE-Q video quality measurement algorithms for best video quality at any given bit rate; ICE Video Manager software enables intuitive configuration, monitoring and troubleshooting, as well as automated generation of video quality results per digital service
<b>ICE VOD System</b>	Advanced video processing for personalized TV	50 percent more SD-VOD and HD-VOD streams per QAM channel; separation of video processing and edge multiplexing designed to enable the highest video quality and most dense, cost-effective and scalable method of expanding VOD and nPVR services; works with existing SRM, VOD servers, QAM devices, and set-tops; management software designed to allow setting of ICE-Q video quality levels per asset or category



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### IneoQuest ([www.ineoquest.com](http://www.ineoquest.com))

Product	Application	Key Features
<b>Singulus G1-T/G10 IQ MediaMonitor</b>	Monitor, field troubleshoot, remote debug, and engineer	Real-time monitoring and measurements of IP video; supports hundreds of IP video flows at 1 Gbps line rate (G10 at 10 Gbps); supports MDI (RFC # 4445); provides analysis and deep packet inspection of IP and MPEG; monitoring and analysis to the transport stream PID level; provides analysis and deep packet inspection of IP and MPEG; (IQ MediaMonitor designed for IPTV)
<b>Cricket Family</b>	Audit, monitor, analyze, and troubleshoot from video source to subscriber	Ethernet, QAM, ASI, 8-VSB, baseband composite video interfaces; real-time monitoring and measurements of video content and transport; monitoring and analysis of video transport to the PID level; remote video verification; video trigger/capture of video transport; video transport metrics: RF metrics, 8-VSB metrics and IP metrics; composite video content QoE monitoring, auditing and troubleshooting tool
<b>Geminus Family</b>	Monitor, field troubleshoot, engineer, and remote debug	Rack mount hardware platforms that can contain up to two systems; real-time IP video monitoring and fault isolation; analysis and remote troubleshooting of 1/10GigE; supports thousands of IP video flows at 10 Gbps line rate; supports MDI (RFC # 4445); TR 101 290 test standard support
<b>iVMS Video Management System</b>	Video quality management system	Provides complete view into the digital video distribution system; designed for rapid fault isolation; features real-time alerts and executive reports; turn-key server with a Web client
<b>IQDialogue SDV Edition</b>	Software probe for analyzing, monitoring and debugging SDV	Targeted real-time monitoring, analysis, auditing and alarming of SDV deployments; measures channel change timing, control plane signaling, mini-carousel; generates alarms for notification and fault isolation; logging and trending of all SDV traffic; support for hundreds of thousands of set-tops and to millions of concurrent tuners from a single probe; integrated with iVMS Video Management System
<b>iCMS Video Content Management System</b>	Distributed content validation system	Baseband video and audio fault monitoring, performance, and auditing; mosaic thumbnail view for immediate visual verification; long-term data storage and video thumbnail archiving; channel scheduling across multiple probes; distributed management of multiple Cricket FrameGrabbers; integrated with iVMS Video Management

### Mixed Signals (<http://mixedsignals.com>)

Product	Application	Key Features
<b>Sentry</b>	Digital content monitoring solution	Comprehensive and scalable monitoring solution; identifies network anomalies at IP and MPEG layers, enables operators to accurately gauge viewers' quality of experience (QoE); real-time monitoring and alerting with historical reporting across entire channel line-up; single rack unit deploys in any hub (big or small) and can be remotely managed.

### Motorola ([www.motorola.com](http://www.motorola.com))

Product	Application	Key Features
<b>CAP-1000 CherryPicker Application Platform v2.0</b>	Video delivery architecture	IP-centric architecture; designed for high-density digital video; delivers advertising insertion, low latency stat muxing, and MPEG-4 and MPEG-2 rate shaping capabilities for SD and HD video; single rack unit; supports hundreds of simultaneous video streams with near instantaneous failover redundancy capability.
<b>DM 6400 CherryPicker Application Platform</b>	Digital video processing system	Medium-density solution for digital video processing systems; designed for networking, distributing and processing both SD and HD services; offers an array of digital video applications including grooming of custom channel lineups, rate shaping and statistical remultiplexing, and localized digital ad insertion.

### Pixelmetrix ([www.pixelmetrix.com](http://www.pixelmetrix.com))

Product	Application	Key Features
<b>VISUALmpeg Qualify</b>	Video quality check at ingest, before play-out and/or archival	Checks video quality for improper chroma levels, blocking and blurring; notifies blackouts, frozen frames and syntax compliance; save template for future content/asset evaluation; templates allow content sharing partners to harmonize evaluation standards
<b>VISUALmpeg Pro</b>	Encoder efficiency and basic video quality analysis in broadcast laboratories and encoder test setups	Ensures encoder accuracy and efficiency; check header information and coding type to avoid operator error; view motion vectors and metadata such as quantizer values and DCT coefficients to have fine-grained control over the encoder; checks for MPEG artifacts (MPEG-1, MPEG-2 and MPEG-4 AVC); runs tests directly on transport streams output from the encoder

**Pixelmetrix (www.pixelmetrix.com)**

<b>DVStation Quality and Audio Monitor Modules</b>	Real-time video and audio quality measurement at the point of ingest	Runs tests directly on SDI input; video quality measured using MOS in real time with intuitive visual cues; blackout and freeze-frame notification via SNMP or CORBA and log generation; audio levels check, with silence alarms
<b>DVStation</b>	Analyze video streams for freeze-frame or blackout conditions	Multi-port system, ASI, QAM, QPSK monitoring and analysis; supports DVB-S.2; complete modulation and transport stream analysis; de-multiplex video streams from MPTSs and analyze them; checks associated metadata and ascertain that video streams are accessible; blackout and freeze-frame checks with logging, SNMP and CORBA; live remote video confidence monitoring
<b>DVStation-IP3</b>	Video over IP quality assurance for cable and IPTV	Monitors all MPTS and/or SPTS streams on a fully loaded GigE link; supports H.264, MPEG-2 SD and HD, SPTS and MPTS; visual content validation and live streaming to PC; video thumbnails with all service attributes; detects freeze frame, blackout and audio loss

**RGB Networks (www.rgbnetworks.com)**

<b>Product</b>	<b>Application</b>	<b>Key Features</b>
<b>Video Intelligence Architecture (VIA)</b>	Core set of video processing capabilities	Works with GigE networking and switching technologies; designed to overcome previous technological barriers and enable high-density solutions to lower the cost of delivering advanced services.
<b>Broadcast Network Processor (BNP)</b>	Transrating and ad insertion	Combines the ability to simultaneously process 500 video streams with statistical multiplexing, transrating, ad insertion and digital overlay capabilities; designed to transrate SD and HD programs to maximize their bandwidth, insert local ads and other mission critical applications.
<b>Dynamic Bandwidth Manager (DBM)</b>	Bandwidth management	Real-time solution for reducing the bandwidth requirements of VOD streams without impacting picture quality or requiring any complicated pre-processing; designed to allow 50 percent more VOD content without increasing bandwidth; can be integrated with various VOD servers.

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RGB Networks ( <a href="http://www.rgbnetworks.com">www.rgbnetworks.com</a> )		
<b>Modular Video Processor (MVP)</b>	Video processing	Combines statistical multiplexing, transrating, grooming and ad insertion capabilities with support for MPEG-4/H.264 and MPEG-2; reliable, carrier-class chassis.

### Scopus Video Networks\* ([www.scopus.net](http://www.scopus.net))

Product	Application	Key Features
<b>Integrated Receiver Processor (IRP)</b>	Dense reception with TS processing, multiplexing, descrambling and transmodulation	Features a variety of front-end options, TS descrambling of two full transport streams, re-multiplexing capabilities, Web-based management, and SNMP monitoring; offers powerful multiplexing including integrated ASI aggregation for up to eight inputs, and PID/service filtering and replacement with PSI/SI and MPEG table generation, for maximum processing versatility
<b>IVG-8000 Intelligent Video Gateway</b>	Routing and processing platform	Designed to cost-effectively deliver digital TV and deploy advanced broadband, broadcast, on-demand, and advertising services; designed to address all headend processing needs in a single platform for digital ad insertion, ASI and GigE aggregation, multiplexing, SD and HD rate shaping, scrambling, and QAM, ASI and GigE transmission
<b>UE-9000 Series Universal Encoder</b>	Encoding, statistical multiplexing, and DSNG	Designed to provide a universal and cost-effective solution for broadcasters and operators to deliver premium HD content; designed to enable smooth migration from MPEG-2 to H.264 encoding, for concurrent transmission of either format over ASI and IP networks; can be integrated into open- or closed-loop statistical multiplexing architectures to provide superior image quality and bandwidth efficiency

\*At press time, Scopus was in the process of being acquired by Harmonic.

### TANDBERG Television ([www.tandbergtv.com](http://www.tandbergtv.com))

Product	Application	Key Features
<b>iPlex Video Processing Platform</b>	Encoding and transrating	High density, multi-functional, IP video processing platform designed for operators augmenting their service delivery; supports stream processing options including MPEG-2 SD encoding and transrating, MPEG-4 AVC SD and HD encoding, and MPEG-2 to MPEG-4 transcoding for SD and HD streams
<b>Reflex Statistical Multiplexing System</b>	Closed-loop statistical multiplexing	Designed to be combined with MPEG-4 AVC and MPEG-2 encoders supporting HD and SD to provide more efficient use of available bandwidth; IP-based connectivity between multiplexers and encoders is designed to support encoders located at remote locations over a WAN; designed for improved picture quality, higher efficiency and reduced capital expenditure
<b>Xport Producer</b>	On-demand encoding solution	Designed to encode, package and deliver content and advertising within existing on-demand and linear broadcast systems; assets can be utilized for VOD, nVOD, Barker and ad insertion systems
<b>RX8250 HD Program Transcoder</b>	Transcoding from MPEG-4 AVC to MPEG-2	Designed to allow cable systems to continue MPEG-2 operation while allowing programmers to distribute using MPEG-4 AVC compression; designed to offer AFD controlled HD to SD down-conversion to generate analog video and audio outputs, providing compatibility with both digital and legacy analog cable tiers
<b>RX8320 ATSC Broadcast Receiver</b>	Migration to ATSC digital terrestrial reception	Designed for full translation capability between digital signaling and analog services; offers automatic picture aspect ratio conversion and signaling via AFD and bar data; designed to ensure that widescreen HD video is correctly displayed when down-converted to 4:3 SD video; closed captions, TV Guide data and program rating (V-Chip) services continue to be supported

### Volicon ([www.volicon.com](http://www.volicon.com))

Product	Application	Key Features
<b>Observer</b>	Video monitoring and logging solution	Captures, stores, and indexes content from multiple channels and offers simultaneous, 24/7 access to video from desktop computers; designed to bring new levels of efficiency to critical broadcasting tasks including monitoring and troubleshooting transmissions, measuring performance, and ensuring QoE.
<b>Observer RPM</b>	Multi-platform QoE solution	Designed to give cable, IPTV, and satellite operators a central location for evaluating QoE for their NOC/headend and remote hubsite broadcasts; continuously scans hundreds of channels and automatically tests signal integrity, issues alerts (via email and SNMP), and captures problematic content.