Cisco Expo 2009

IP Video Contribution for Broadcasters

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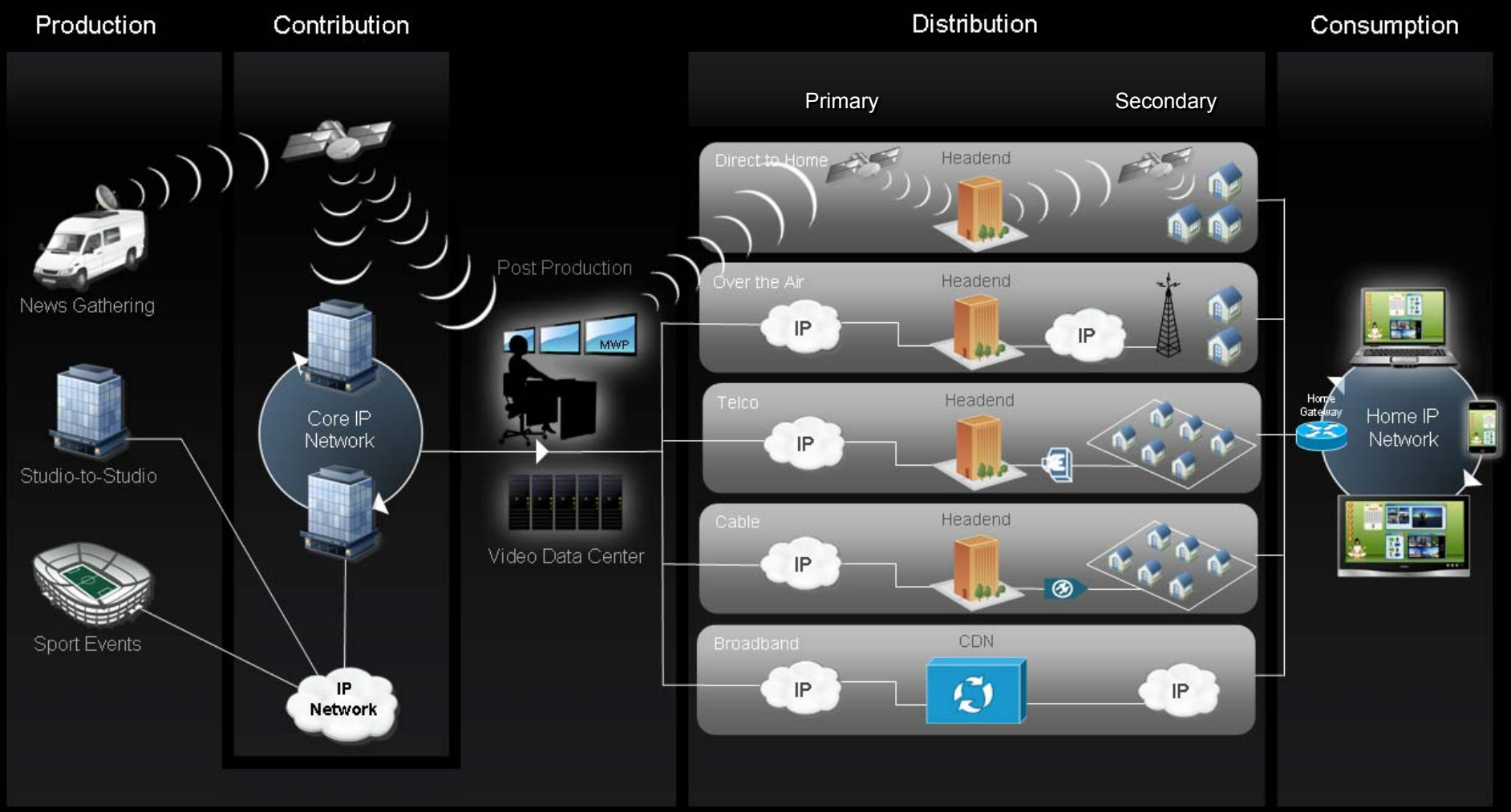
Presentation Outline

- Video Contribution Landscape
- Video Compression Technologies
- JPEG 2000 Compression Format
- DCM IP Video Gateway
- D9093/D9094 AVC Contribution Codec

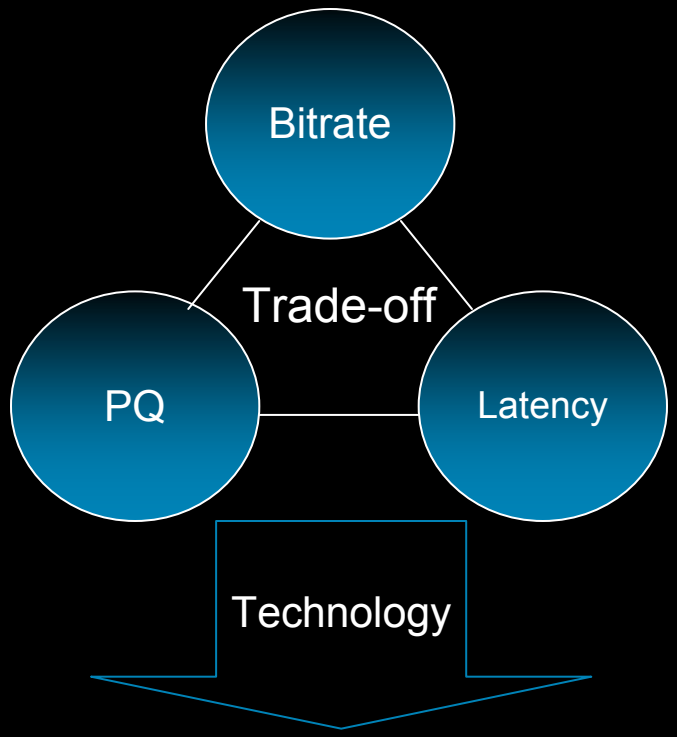
Contribution and Distribution Network

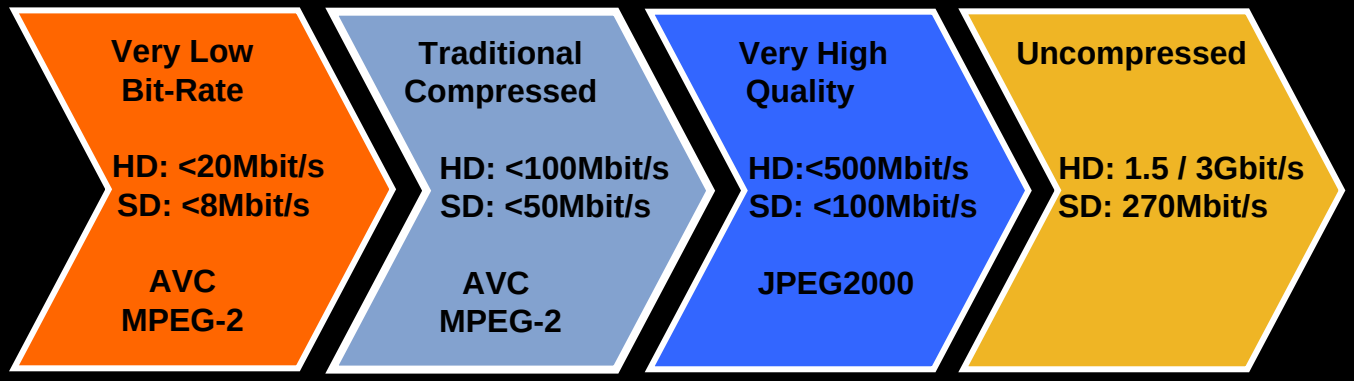
High-Level Diagram



Compression technology

Choosing the Right Horse





IP Contribution landscape – HD example

Terrestrial:
Post production
Inter-studio contribution
Sports contribution
Regional News

Satellite:
Special events
Inter-studio contribution
Sports contribution

DSNG, DTNG:
Field news coverage

Uncompressed

- Error Correction: Standardization
- Transport: Standardization RTP/UDP

JPEG2k

- 4:2:2 10 bit resolution
- I mode only
- Error Correction: Standardization
- Transport: Standardization
  MXF/ MPEG-2 over RTP/UDP

MPEG-2

- 4:2:2 8-bit resolution
- I/P/B mode
- Error Correction: SMPTE 2022
- Transport: MPEG-2 TS over RTP/UDP

MPEG-4 AVC

- 4:2:2 8-bit or 10-bit resolutions
- I/P/B mode
- Error Correction: SMPTE 2022
- Transport: MPEG-2 TS over RTP/UDP

MPEG-4 AVC

- 4:2:0 8-bit resolution
- I/P mode only
- Error Correction SMPTE 2022
- Transport: MPEG-2 TS over RTP/UDP

Bit rates

1.5G/3G

<500Mbps

<100Mbps

<20Mbps

Latency

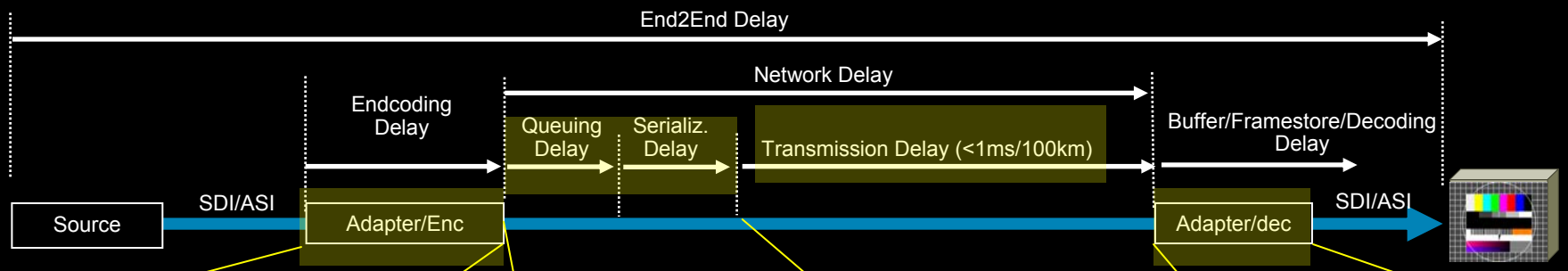
Ultra low latency <150msec

Very low latency <300msec

Low latency <800msec

Cisco Confidential

Latency (E2E Delay) using an IP Network



Uncompressed:
<<1 msec

JPEG2000 encoding*:
55 msec @ 25Hz
50 msec @ 30Hz

< 1ms

FEC will of course also add delay to the end-to-end, very dependent on FEC configuration.
With Pro-MPEG FEC CoP4 the maximum matrix size can be as large as 1500 RTP packets, which equals 1375 bytes x 1500 packets (max):
- 61 ms at SDTV 270Mbit/s
- 12 ms at HDTV 1.485Gbps.

Realistic FEC delays are in the range of 5 ms – even with JPEG2K compressed HD.

Dejittering buffer:
10-200ms

JPEG2000 decoding*:
20 msec @ 25Hz
18 msec @ 30Hz

Gen-lock delay:
Up to 40 msec @ 25Hz
(optional)

		Network delay	Dejittering buffer	Compression/ Packetization	FEC	Gen-lock	Total
Uncompressed	Typical	< 5ms	20 ms	<< 1ms	5 ms	<33 ms	<63 ms
Uncompressed	Best case	< 1ms	10 ms	<< 1ms	None	0 ms	5-10 ms
JPEG2K @30Hz	Typical	< 5ms	20 ms	68ms	5 ms	<33 ms	<140 ms
JPEG2K @30Hz	Best case	< 1ms	10 ms	68ms	None	0 ms	80 ms

* These are depending on implementation and not set by the standard (can be higher)

Cisco Full Range of Contribution Products

Typical Latency & Bit-Rate Criteria

Latency

MPEG-4 AVC

D9054 AVC Encoder

B/W: 4 to 20 Mbps
Lat: > 1 sec

D9094 AVC Contribution Codec

B/W: 4 to 38 Mbps
Lat: 270 to 500 msec

JPEG 2000

DCM Gateway

B/W: 40 to 500 Mbps
Lat: 80 to 140 msec

Uncompressed

DCM Gateway
B/W: 1.5 to 3 Gbps
Lat: 5 to 70 msec

Bitrate

Video Compression Technologies

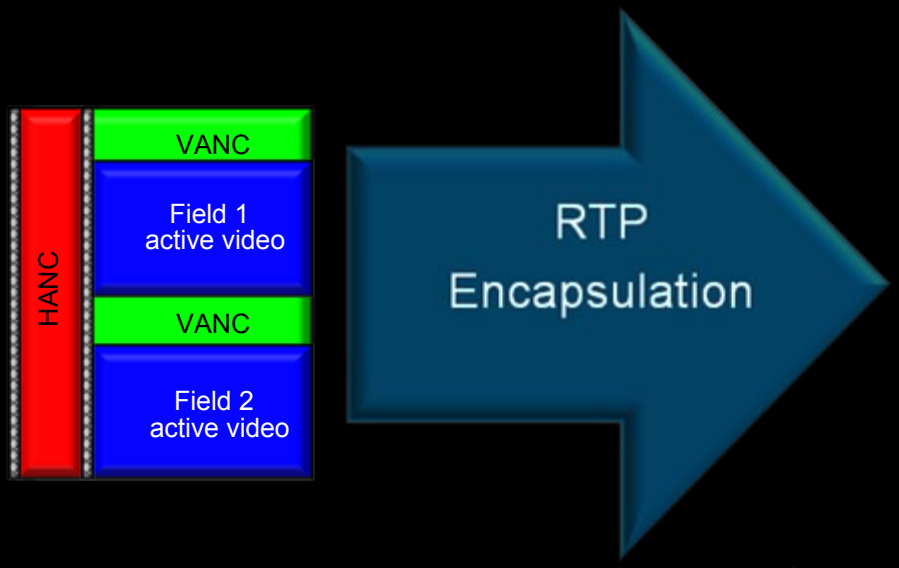
Uncompressed Video

SDI Video - Related Standards

Terminology	Standard	Bit Rates	Video Formats
SD-SDI	SMPTE 259M	270Mbps	480i29.97, 576i25
HD-SDI	SMPTE 292M	1.5Gbps	720P50/59.95, 1080i25/29.97
Dual Link HD-SDI	*SMPTE 372M*	*2 x 1.5Gbps*	*1080P50/60*
3G-SDI	SMPTE 424M	3Gbps	1080P50/60

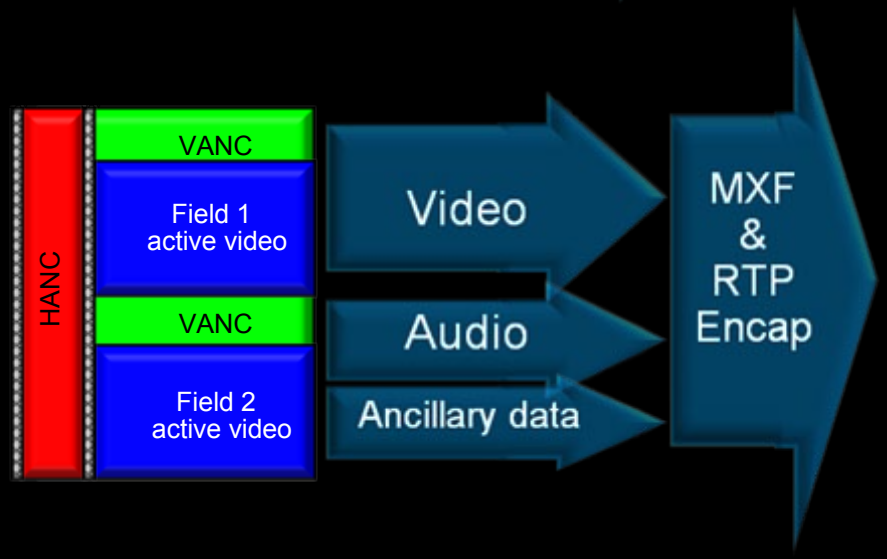
SDI Video

Uncompressed vs JPEG2K compressed



Uncompressed:

- **All samples** from the SDI signal is RTP encapsulated.
- This also means that by default we support SDTI, as the transport and encapsulation cannot see the difference between an 270Mbit/s SD-SDI signal or an 270Mbit/s SDTI signal.



JPEG2K Compressed:

- Video samples are JPEG2K compressed
- Embedded Audio channels are user selected and not compressed.
- Anciallary data are user selected and not compressed or slightly compressed (TXT).
- All elements from one frame are MXF wrapped and RTP encapsulated.

MXF

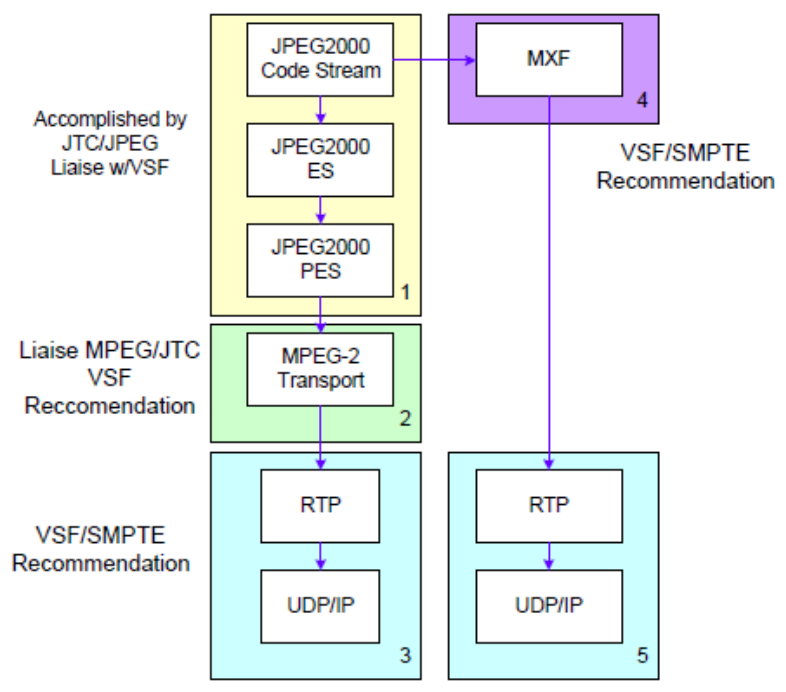
Material eXchange Format

- **What is MXF?**
  - Wrapper for video, audio, ancillary data and metadata
  - An interchange file format
  - Primarily designed for storage and file transfer
  - Used in Camcorders like Panasonic P2, SONY XDCAM HD, Grass Valley Infinity
  - Used in various digital workflow systems like Avid, in the Adobe Premiere Pro video editing suite, as well as in Apple Final Cut Studio
  - Standardized within SMPTE
- **What is MXF over RTP?**
  - Adaptation of MXF for RTP video streaming
  - Collect all data for one frame (compressed video (eventually JPEG2K), audio, ancillary data, etc.) in one MXF Content Package

RTP Encapsulation

MPEG-2 TS & MXF

- This is currently being standardized!
- The standardization work is done within VSF (Video Service Forum) and EBU
- There are two paths under consideration
  - MPEG-2 TS
  - MXF
- Within VSF there is working to finalize the MPEG-2 TS first, and the MXF secondly



- Within EBU the priority is the opposite. EBU, with the broadcasting community behind them is a strong speaker for MXF, especially because it can carry other existing formats and have metadata embedded in the stream

JPEG 2000 Compression Format

JPEG2000

Today's Compression Formats Comparisons

	MPEG-2 / AVC	AVC I-only	JPEG-2000
Compression Ratio	Highest	Medium / High	Medium / Low
Compression Latency	Large	Low	Low
Resolution	8-bit	8-bit (10 bit in 4:2:2profile)	10-bit
Compression Basis	Block & Entropy (AVC)	Block & Entropy	smoother
Picture Quality Dependency	Affects multiple frames	Single Frame only	Single Frame only
Cascading (multiple encode/decode chains)	Quality Loss	Quality Loss	Quality Loss - Possible w/o quality loss
Error Correction	SMPTE-2022	SMPTE-2022	Under standardization
Transport Layer	MPEG-2 TS over UDP/RTP	MPEG-2 TS over UDP/RTP	MPEG-2 TS or MXF over UDP/RTP
License Scheme	Yes	Yes	Free
Open Technology	Yes	Yes	Yes

JPEG2000 versus MPEG-4 AVC (INTRA & IP)

Study conducted by Ali Jerbi, Ph.D

- Purpose of study:
  - Evaluate performance of these two compression technologies for HD sequences at a range of bitrates of ~50-250Mbps

- Results:
  - Recommendations for deployment of JPEG2k versus MPEG-4 AVC compression technologies for specific bitrate ranges

JPEG-2000 vs MPEG-4 I/IP
Conclusion

- AVC Intra
  - JPEG-2000 and MPEG-4 Intra performs similarly at high bitrates (100Mbps and higher)
  - MPEG-4 Intra generally outperforms JPEG-2k slightly at lower rates (50Mbps and lower)
  - When visual frequency weighing is enabled, JPEG-2k produces, in some cases, better visual quality than MPEG-4 Intra. Need to use QP scaling for MPEG-4 AVC for a more fair comparison
- AVC IP-frames
  - MPEG-4 AVC IP significantly outperforms JPEG-2k especially at low and medium rates (~80Mbps and lower).
  - May add one frame of latency.
- JPEG 2000
  - Very LOW latency at high bitrates
  - Robust, scalable quality, lossless compression
  - Inexpensive

JPEG2000 Compression Theory

Compression process

Wavelet filtering

↓

Quantization

↓

Bitplane encoding

↓

Codestream building

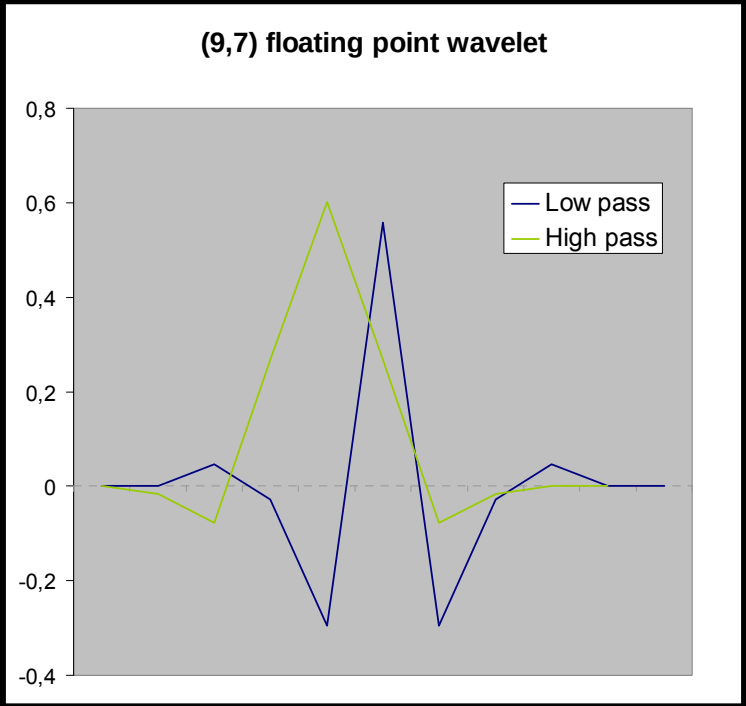
JPEG2000 Compression Process

- **Tiling**
  - The image YCbCr *can* be split into tiles, rectangular regions of the image that are transformed and encoded separately. Typically one single tile is used. (full frame – best quality)
- **Wavelet based image compression standard**
  - A **wavelet** - is a mathematical function used to divide the picture into different frequency components (sub-bands). Then wavelet coefficients are generated for all frequency sub-bands.
  - By itself the Wavelet Transform does not compress image data; it restructures the image information so that it is easier to compress
- **Quantization and Entropy encoding**
  - A study of each component with a resolution that matches the compression bitrate.
  - The quantized sub-bands are split into rectangular regions. Each of these rectangular regions are then further broken down into code blocks and then entropy coded. This is context modelling and arithmetic coding on a code block.

JPEG2000 Compression Theory

Wavelet Filters

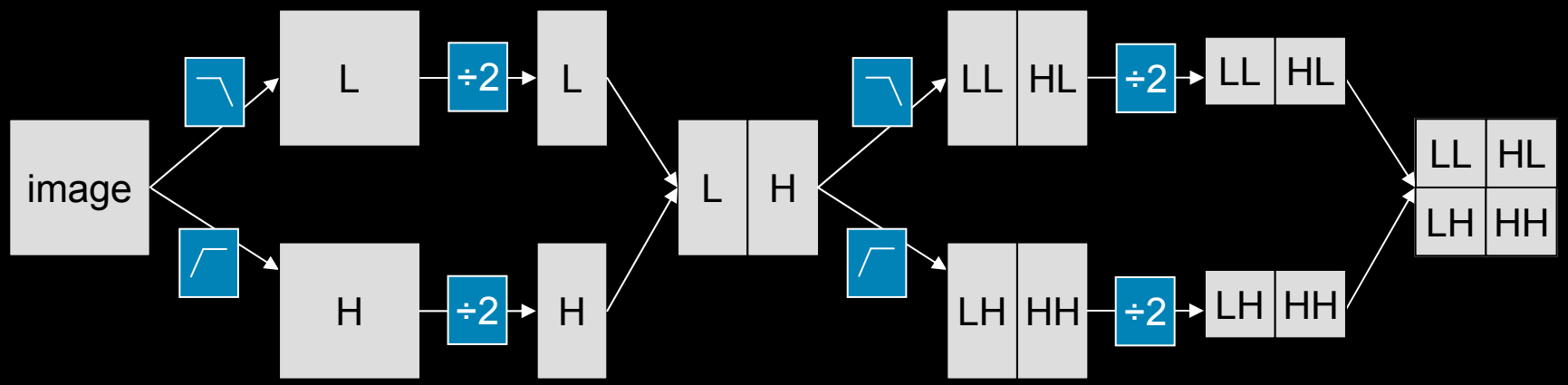
- The filters are one-dimensional and are applied in the horizontal and vertical directions.
- JPEG2000 provides both lossy and lossless compression based on the filters applied.
- The Daubechies (9,7) floating point filter gives best compression performance.
  - Called the irreversible transform
- The Le Gall (5,3) integer filter provides lossless compression
  - Called the reversible transform
- Result of convolution process
  - The low pass filter removes all but the low frequency content.
  - The high pass filter can be considered as local Fourier transform.



Only lossy compression is currently foreseen to be used for IP contribution

JPEG2000 Compression Theory

The Wavelet filtering process




Low pass filter

High pass filter

÷2 Downsampling

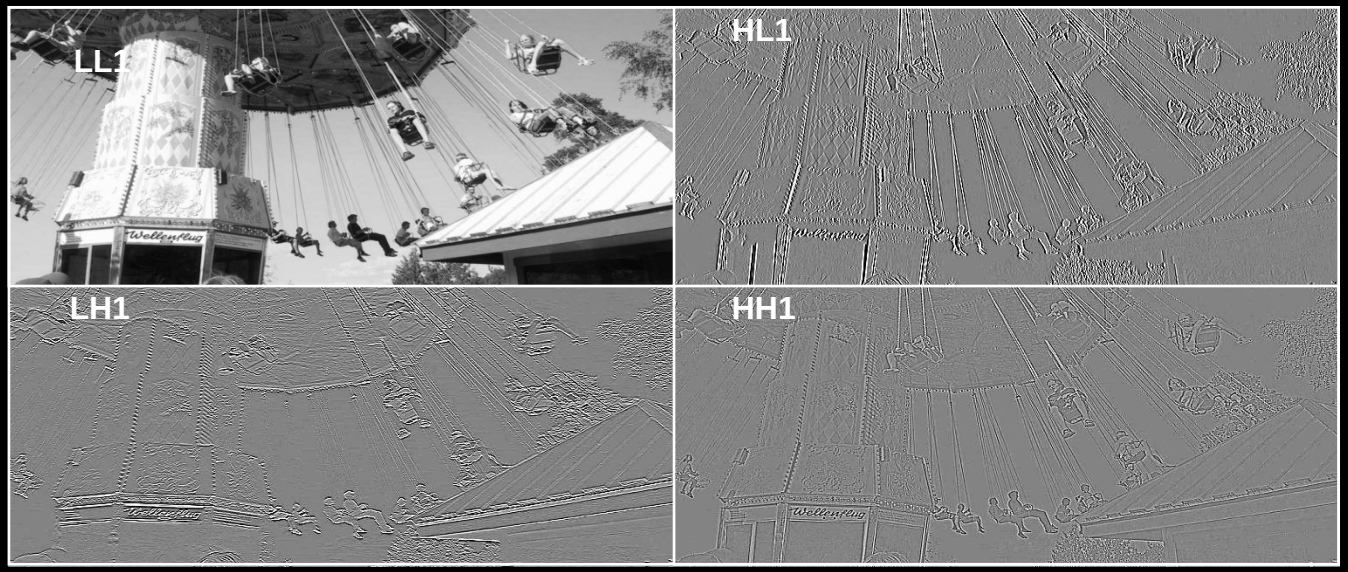
- The output contains a low pass copy of the input + 3 high pass subbands in the frequency domain
- The result contains the same number of elements as the source image
- The inverse process will rebuild the input picture provided the lossless filter pair is used
- Compression is gained by an effective representation of the content in the low frequency sub band and the 3 HF frequency sub-bands

JPEG2000 Compression Theory

Wavelet filtering result

Lower resolution picture

Horisontal High Frequencies



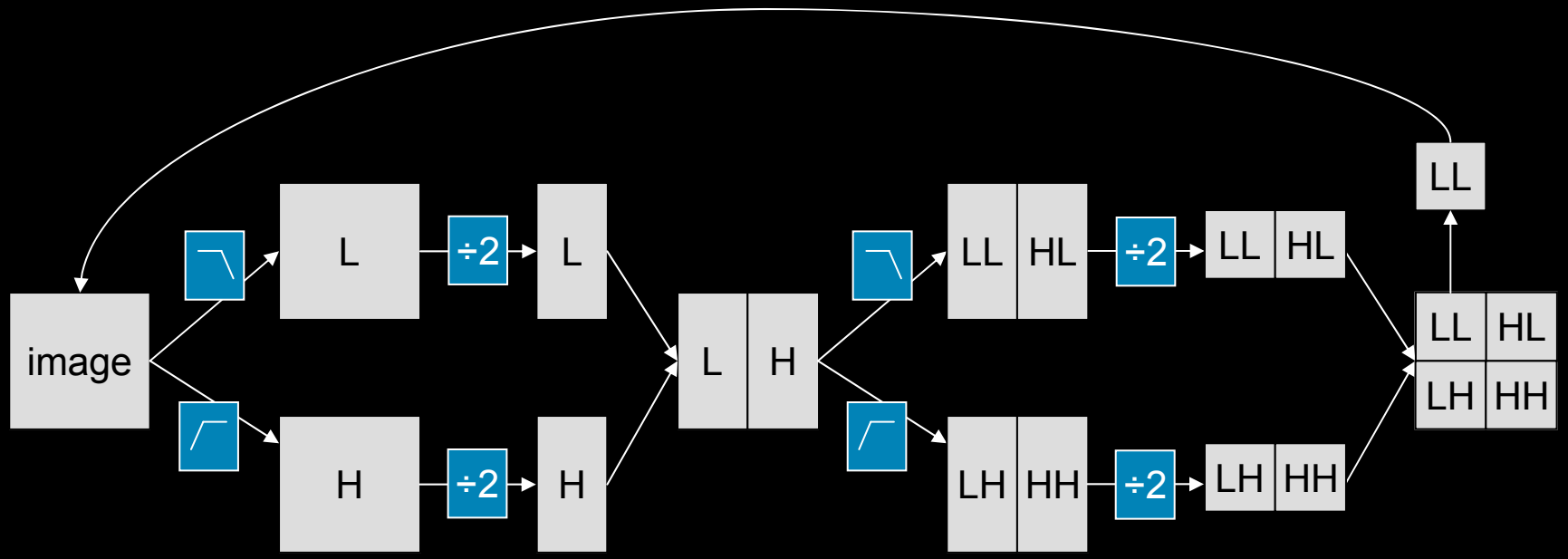
Vertical High Frequencies

Diagonal High Frequencies

- High pass and low pass filters are applied to rows and columns, producing four sub-bands.
- Process is repeated on the “low low”, or LL sub-band.

JPEG2000 Theory

The Wavelet filtering process is repeated

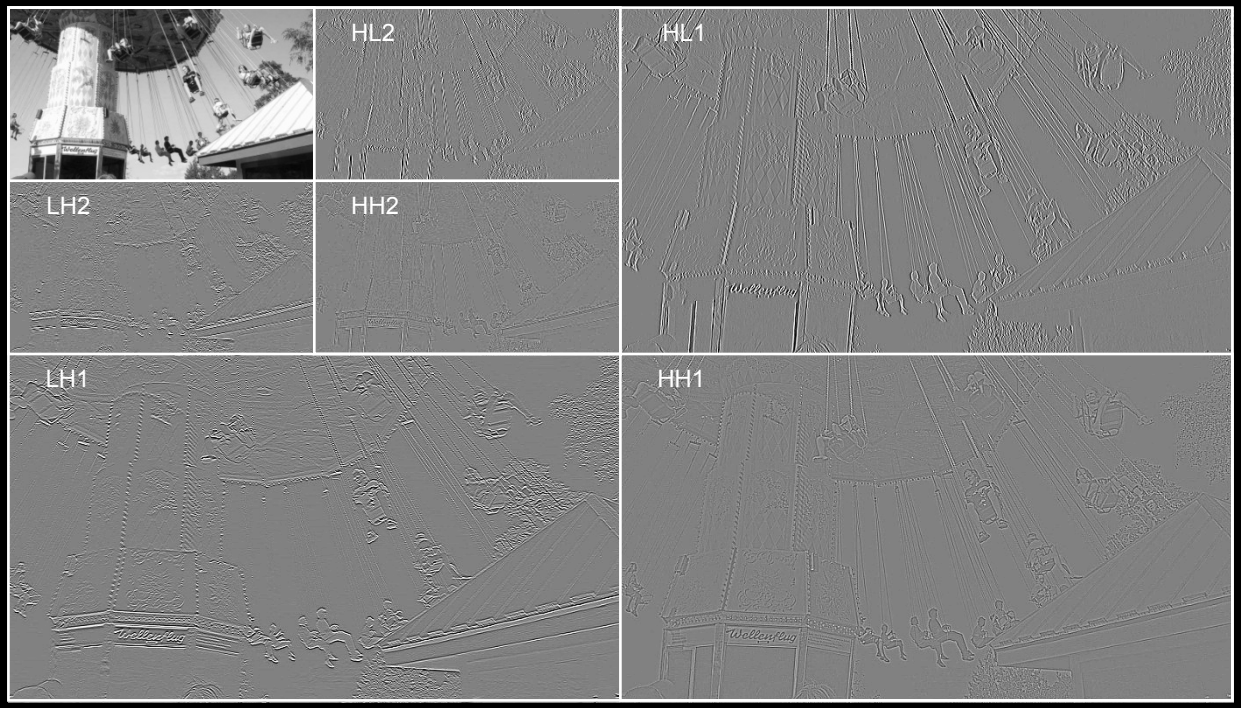


- The filtering is repeated multiple times in order to create a more bit effective representation of the LL subband.

JPEG2000 Theory

Wavelet Transform Example - Two Levels (Three Resolutions)

High frequencies scaled for display

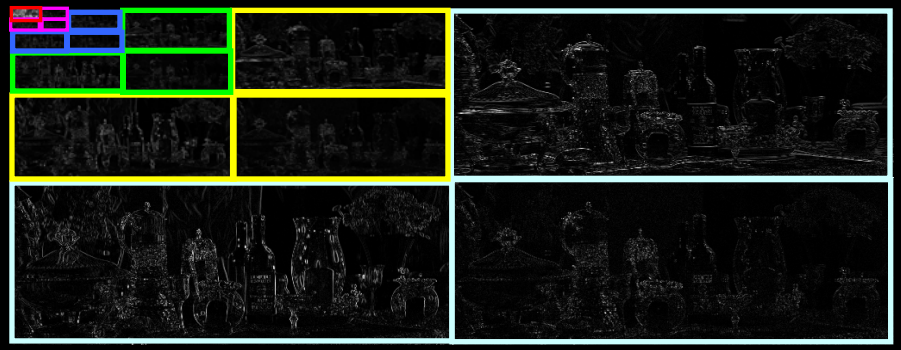


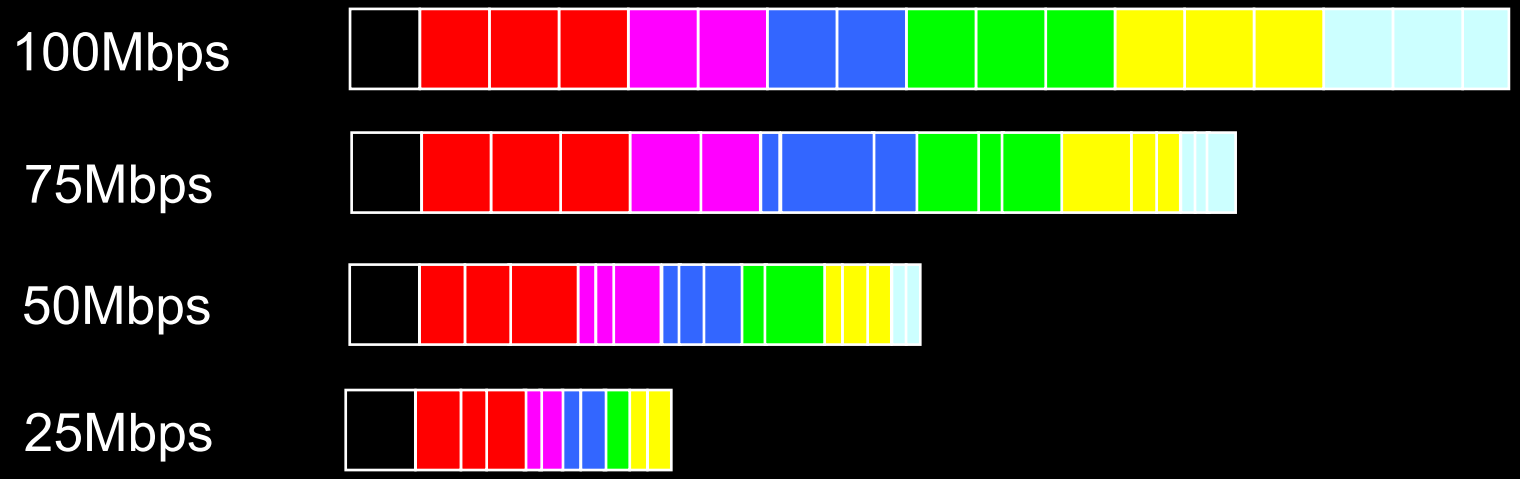
- The LL sub-band is the most important for recreating the image.
- Other sub-bands provide detail and resolution.
- Sub-bands are further divided into quality layers.

JPEG2000 Theory

Entropy Encoding

- For the bit rate selected, the optimal quality codestream is produced
- Possible because subbands are divisible into “quality layers”
- Entropy encoding determines how much of each quality layer is included





JPEG2000 Theory
Conclusion

- The combination of JPEG2000 compression and IP networks is a very good solution for high bitrate contribution of content.

- Main advantages of JPEG2000 include
  - low latency
  - high video quality (4:2:2 &10 bit video resolution)
  - high error resiliency

DCM IP Video Gateway

DCM Gateway
Video over IP

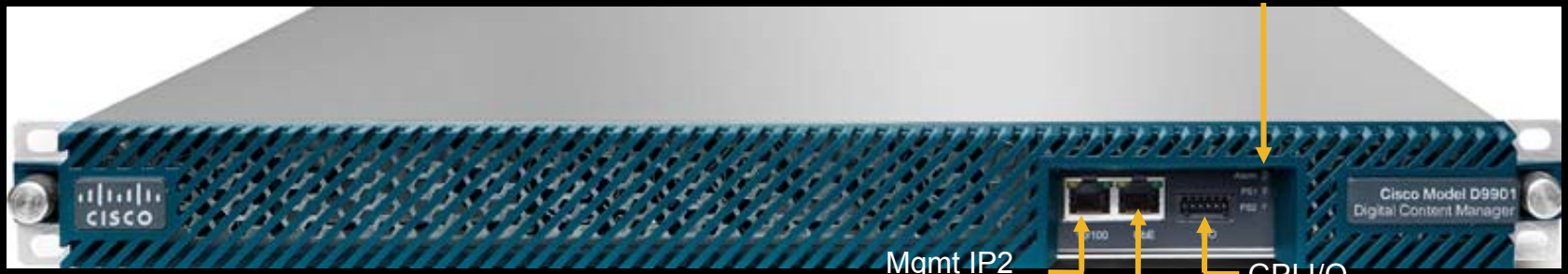
- 1RU DCM with up to two gateway blades
  - Each blade has dual IP-ports equipped either with 1GbE SFP's or 10GbE SFP+'s.
  - Up to 6 ports SD, HD 720p/1080i per blade
  - Optional J2K module
  - Up to 3 3G-HD 1080p per blade
  - Video ports can be electrical or optical
  - ASI transparent transport
- S/W licenses enable
  - More video channel processing
  - HD on top of SD, 3G on top of HD
  - 10Gig on top of 1Gig (+ exchange SFP to SFP+)
  - FEC (CoP4)
- Transport of video, embedded audio and VBI
- Advanced adaptive clock recovery & Gen-lock

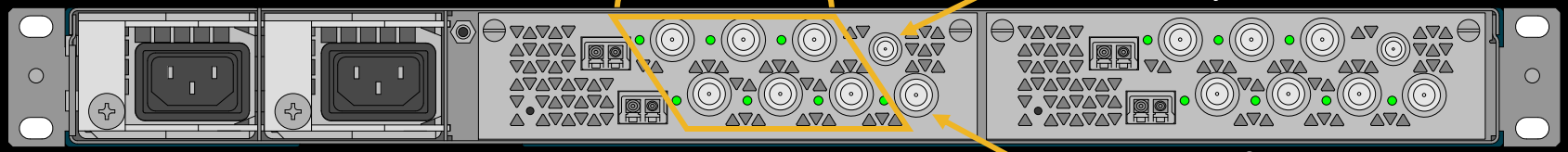
- Very compact SDI gateway
  - 12 Video stream / 1RU
- Best in class IP connectivity and redundancy features
  - Hitless switchover (@1GbE) 100ms delay
- Unique upgrade path
  - S/W as well as H/W
  - Future proof investment
- Flexible & scalable architecture
  - Allows video quality improvements through software downloads
  - Allows adaptation to evolution of transport protocols through software downloads
  - Future proof investment

DCM Gateway

Front & Rear

DCM 1RU





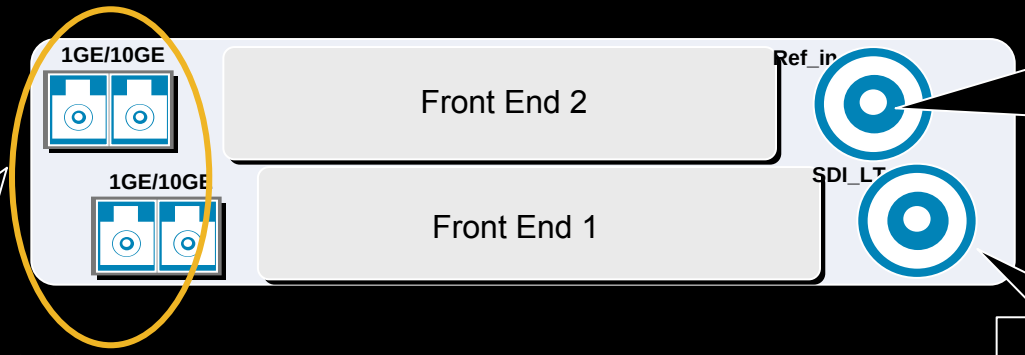
DCM Gateway

Product Description – H/W modularity

- Fixed card connectors

SFP cages can house:
SFP for 1G
or
SFP+ for 10G

The Gateway card will support both types.
Add license to run 10G



Fixed Ref Input used as Clock Ref Input for SD & HD SDI Outputs.

B&B for SD.
Tri-level sync for HD or mixed SD/HD

Fixed SDI Output Monitoring (LT) Output

- 3 types of front-ends

ELECTRICAL

3 x SDI **OUTPUTS**
or LoopThrough ports

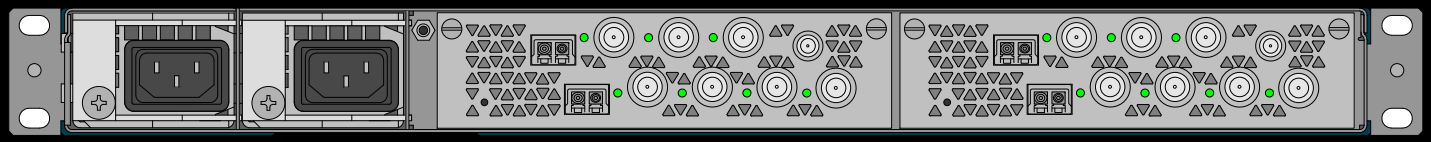
3 x SDI **INPUTS**

OPTICAL

3 SFP Cages (insertable)
Individually either **OUTPUT** or **INPUT**

DCM Gateway – JPEG 2K Plug-in

Codec Daughter Cards



“SDI Gateway”

JPEG-2000 Plug-on

- JPEG-2000 compression module
- Daughter board for “SDI gateway”

DCM Gateway
JPEG2000 Compression Engine

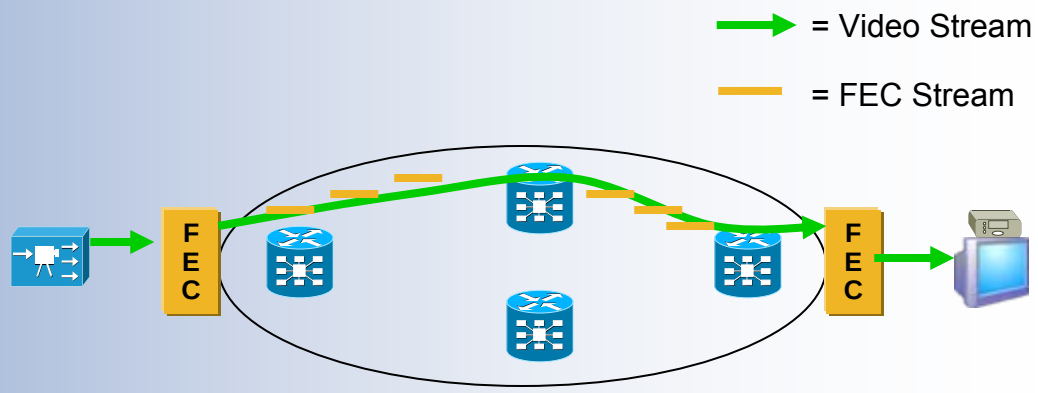
One common resource pool of 1.8Gbps – 6 inputs or 6 outputs

- Examples:
  - 6 video streams to a bit-rate of 300Mbps each, or
  - 5 video streams to a bit-rate of 360Mbps each, or
  - 4 video streams to a bit-rate of 450Mbps each, or
  - 3 video streams (HD/3G) to a bit-rate of 600Mbps each, or
  - 2 video streams (HD/3G) to a bit-rate of 900Mbps each, or
  - 1 video stream (3G) to a bit-rate of 1.8Gbps.
  - Or any combination that sums up to 1.8Gbps!
- Notice, that the uncompressed video processing can handle up to 6xHD/SD or 3x3G-HD.

DCM Gateway
Video Quality Experience

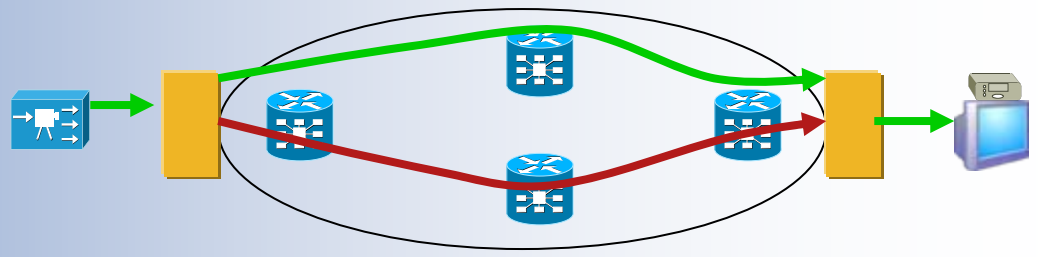
Forward Error Correction (FEC)

- Compute/send extra FEC bits, used to recover lost packets
- Some overhead and additional delay
- Use FC/FRR to bound protection period
- Most useful for recovering from intermittent packet loss, i.e., due to bit errors



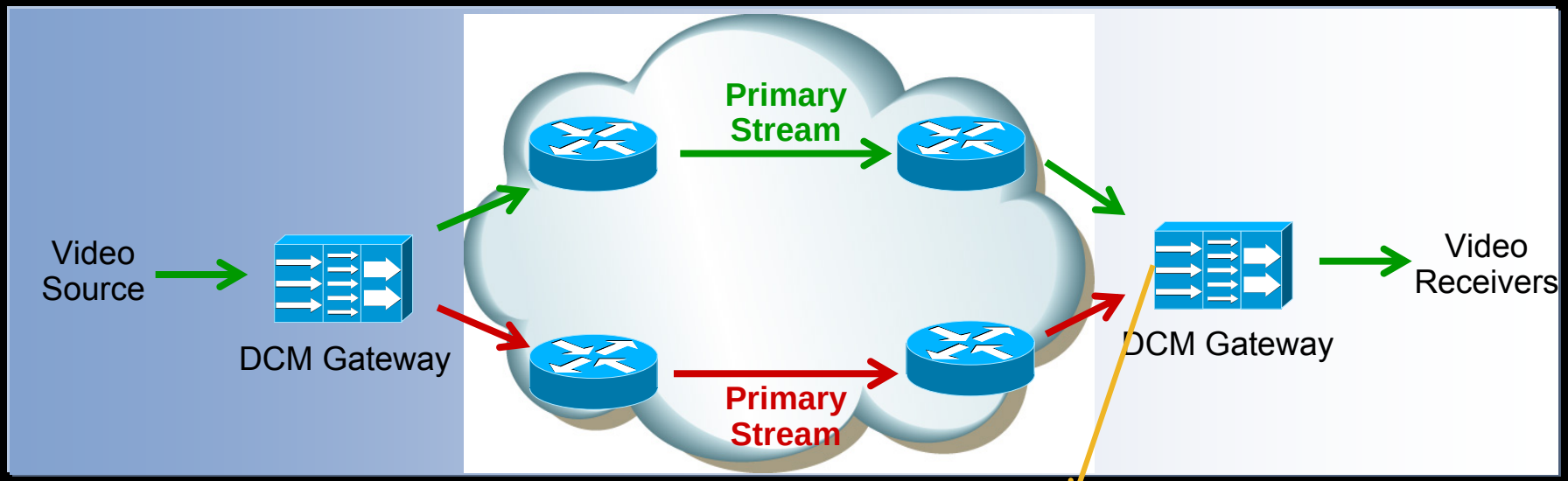
Spatial Redundancy (Live-Live)

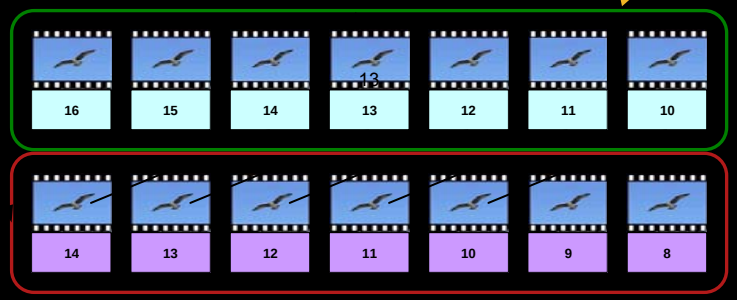
- Duplicate stream and send over disjoint paths
- Requires path diversity
- Most useful for recovering from burst losses, i.e., due to network failure events
- Multiple network technologies to support path diversity: MoFRR, MTR, MPLS TE



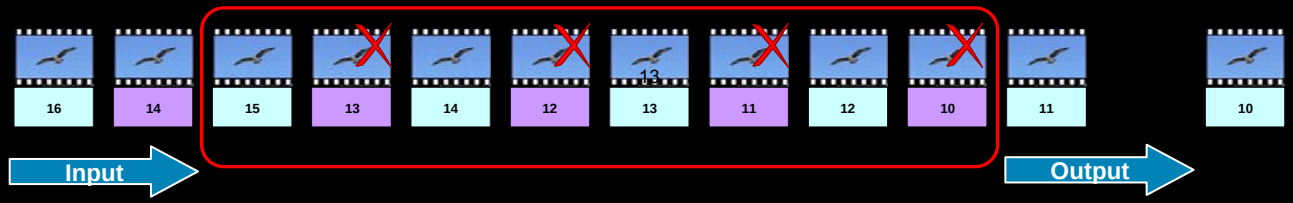
DCM Gateway

Hitless Switch-over on 1GbE





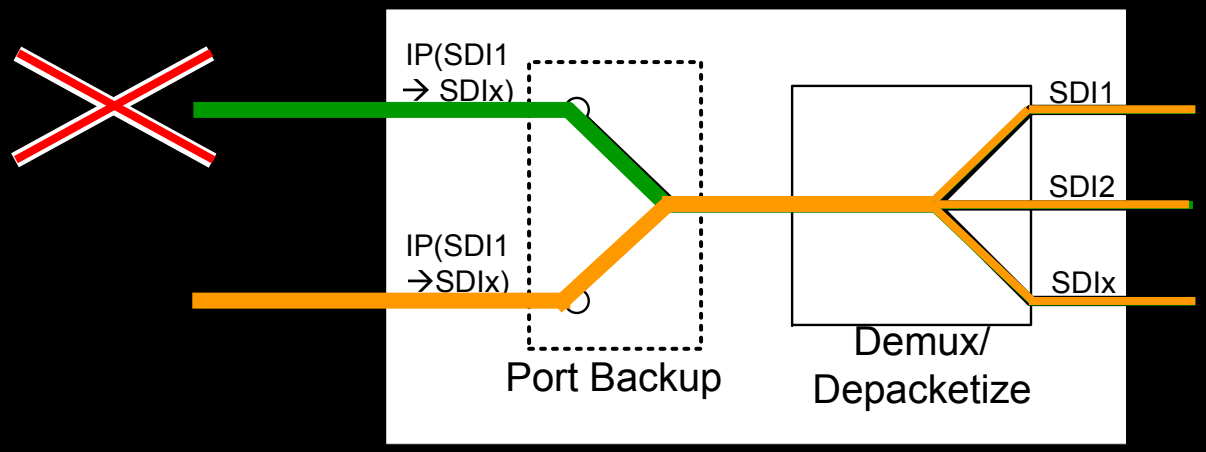
Due to network delay differences the two received streams are misaligned



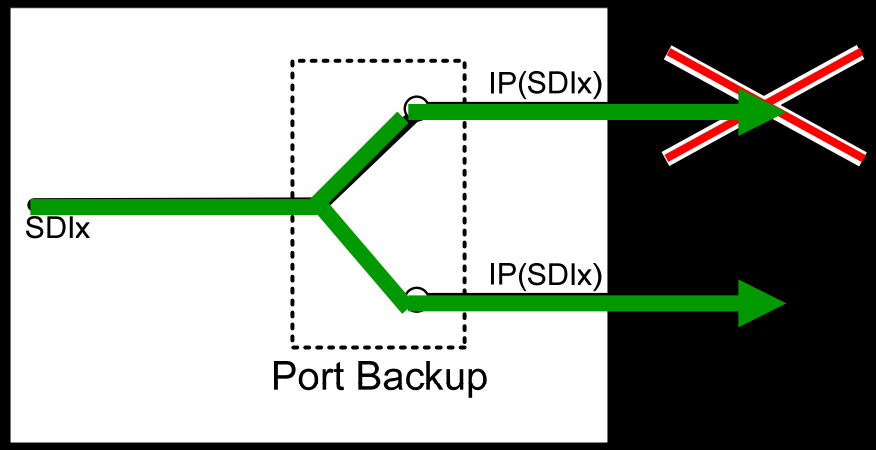
Misalignment is compensated for in the DCM Gateway receiver – up to 100ms, and a hitless switchover between the two feeds is performed in case of detected failures.

DCM Gateway
IP Port Redundancy

- IP RX: Based on link loss and UDP loss

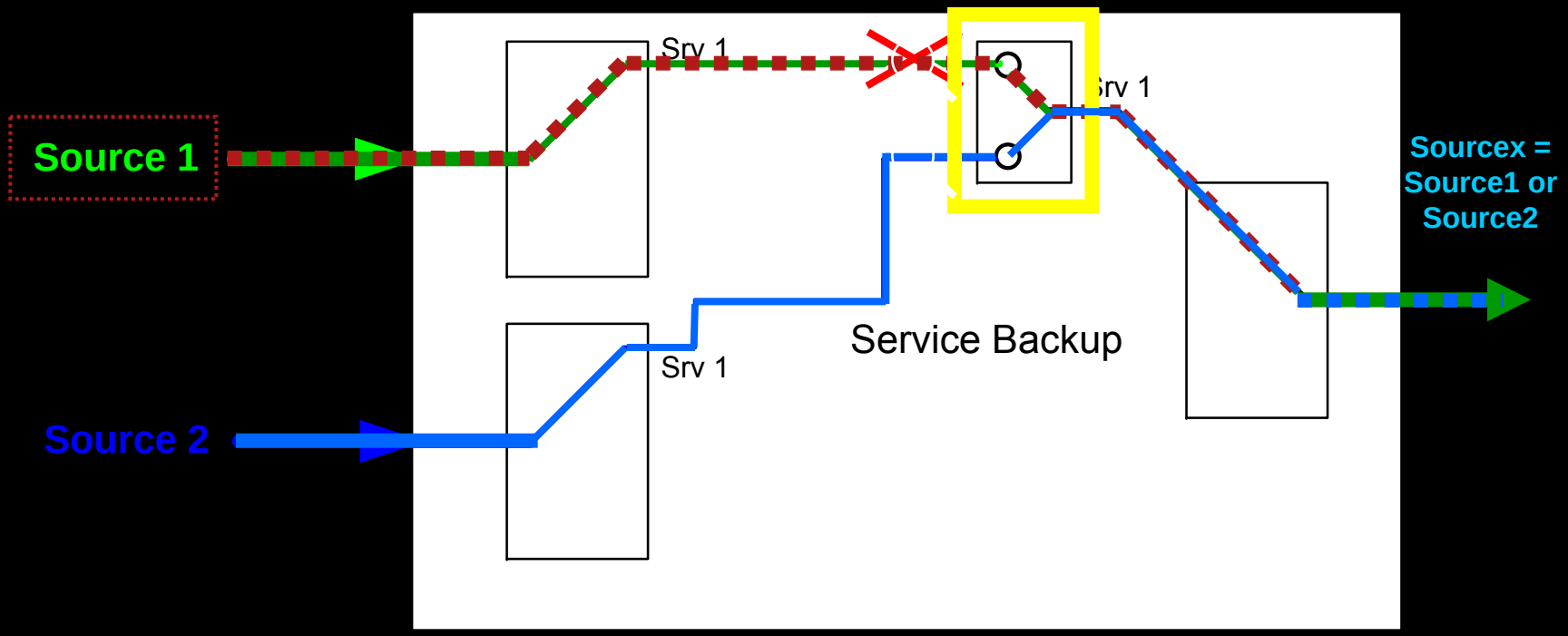


- IP TX: Based on link loss



DCM Gateway
Service Redundancy

Principle Of Operation



- Monitoring at the ‘input service’ level: SDI
- Output takes services from source 1 (primary) and passes to output
- A problem with service 1 from source 1 (primary) – e.g. camera/cable failure
- Monitor detects “service loss” alarm (configurable) – e.g. SDI sync loss
- Service 1 output is replaced with Service 1 from Source 2 (backup)

D9093/D9094/D9894 AVC Contribution Codec

Product overview Encoders

	Model	Input	Video	Audio	Output
	D9054 HD AVC Encoder	HD-SDI, Emb. Audio, 4 st. AES Audio	4:2:0 - MP4 CBR / VBR / Statmux 720p, 1080i	Up to 6 stereo, LII, AAC+, AC-3, Linear PT: Dolby-E, AC-3	ASI, IP (Dual 100BT)
	D9034 SD AVC Encoder	SD-SDI, PAL/NTSC, Emb. Audio, 4 st. ana/AES audio	4:2:0 - MP4+PIP VBR / Statmux MP2 (s/w option)	Up to 4 stereo, LII, AAC+, AC-3, Linear PT: Dolby-E, AC-3	ASI, IP (Dual 100BT)
	D9032 SD MP2 Encoder	SD-SDI, PAL/NTSC, Emb. Audio, 4 st. ana/AES audio	4:2:0 / 4:2:2 – MP2 CBR / VBR / Statmux Low delay, BISS-E	Up to 4 stereo, L II, AC-3, Linear PT: Dolby-E, AC-3	ASI, IP (Dual 100BT)
	D9040 SD MP2/AVC Encoder PowerVu	SD-SDI, PAL/NTSC Emb. Audio, 4 st. ana/AES audio	4:2:0 / 4:2:2 – MP2 MP4(future) PNC Cntrl, Statmux	Up to 4 stereo, L II, AC-3, Linear PT: Dolby-E, AC-3	ASI
	D9050 HD MP2 Encoder	HD-SDI Emb. Audio, 4 AES Audio	4:2:0 / 4:2:2 – MP2 CBR / Statmux 720p, 1080i	Up to 4 stereo, LII, AC-3, Linear PT: Dolby-E, AAC, AC-3	ASI
	D9022 SD MP2 Encoder CBR	SD-SDI, PAL/NTSC, Emb. Audio, 2 st. ana/AES audio	4:2:0 – MP2 CBR Lowest cost	2 stereo, LII, AC-3, Linear PT: Dolby-E, AC-3	ASI, IP (Dual 100BT)
 Available now	D9093 D9094 D9894 Contribution encoder and decoder	SD/HD-SDI, Emb. Audio, 1 st ana audio	MP4 4:2:0, 4:2:2(fut), 525i/625i, 720p, 1080i, Latency <500msec	Up to 4 stereo, LII and AAC, PT: D-E	IP (10/1001000bT) + FEC Cop-3, ASI
Contact BU	Next Generation	SDI, HD-SDI, IP	MP2, MP4 SD, HD 4:2:0, 4:2:2	Up to 4 stereo, LII and AAC, PT: Dolby-E	IP (10/1001000bT) + FEC Cop-3, ASI

(*) Shared resources in the platform

Low Delay Contribution AVC Codec

D9094, D9093, D9894

- SD and HD support
  - HD AVC 4-27 Mbps (4:2:0)
  - HD AVC 12-38 Mbps (422csc)
  - SD AVC 1.3-10Mbps (4:2:0)
- Encode-Decode Latency as low as 280ms (ASI), 500ms (IP)
- 4 stereo channels
  - Layer II or AAC audio channels
  - DOLBY E & AC-3 pass-through
- DVB-S/S2, IF or L-band modulator
- ASI and IP transport w. FEC
- WEB based GUI and SNMP
- Low power
- Gen-lock in decoder

- **Market leading** audio/video MPEG-4 AVC codec that performs real-time transmission of HDTV at low bit rates and **low delays** over:
  - DVB-S/S2 or DVB-ASI
  - or broadband IP networks.
- **Powerful error correction** functions ensure high quality of service over IP networks by preventing the distortion of decoded images, even when network packet losses occur.
- **Flexible Codec architecture** allows user selection between encoder and decoder functionality

Low-delay AVC contribution codec

D9093, D9094, D9894

- D9093 SD Contribution AVC Codec
  - SD encoder & decoder user switchable mode

- D9094 SD/HD Contribution AVC Codec
  - HD AND SD encoder & decoder - user switchable mode

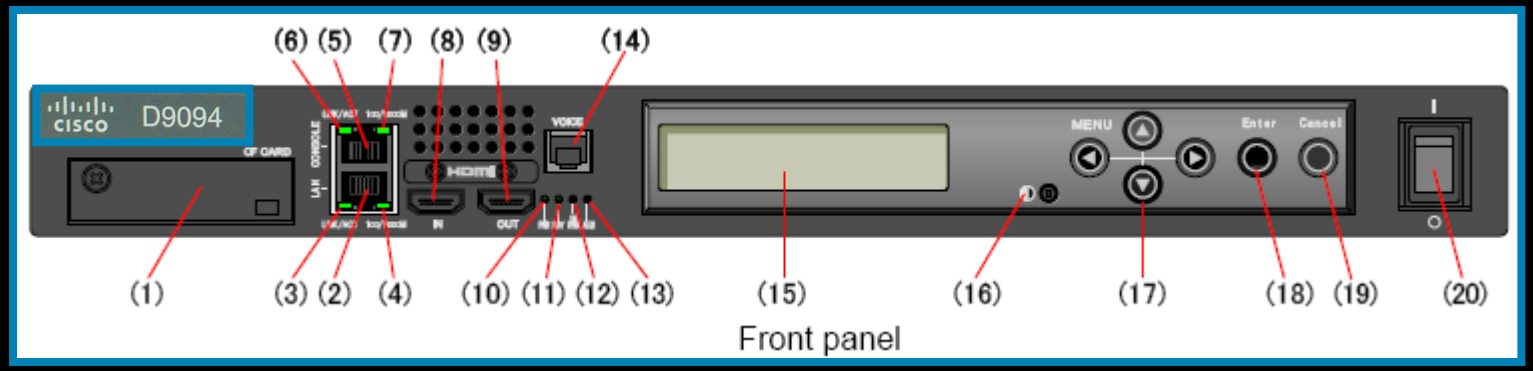
- D9894 SD/HD Contribution AVC Decoder
  - Dedicated HD and SD AVC decoder

- Options
  - DVB-ASI card
  - DVB-S/S2 Modulator card (IF or L-band)

Hardware Description and Specifications

Front Panel

1. CF CARD slot – Future Option
2. LAN port (LAN)
   - Ethernet 10BASE-T/100BASE-TX /1000BASE-T
3. LAN Status LED (LINK/ACT)
4. LAN Speed LED (100/1000M)
5. CONSOLE port (CONSOLE)
   - Ethernet 10BASE-T/100BASE-TX /1000BASE-T
6. CONSOLE Status LED (LINK/ACT)
7. Speed LED (100/1000M)
8. Digital HDMI input (HDMI IN)
   - 50Ω unbalanced.
9. Digital HDMI output (HDMI OUT)
   - 50Ω unbalanced.
10. Power LED (PWR)
    - Turns on when the device is powered on.
11. Status LED (RDY)
    - Turn on when D9094 power is on.
12. AV input status LED (INDWN)
    - Audio/Video input setting status
13. Alarm LED (ALM)
    - Turns on when D9094 operation is abnormal.
14. Voice input/output (VOICE)
    - Voice communication (Intercom) port between D9094/D9894's.
15. LCD panel
    - Used to set D9094 up and displays status
    - 2 lines x 20 characters.
16. LCD brightness controller
17. Directional key
18. Enter key (Enter)
19. Cancel key (Cancel)
20. Power button

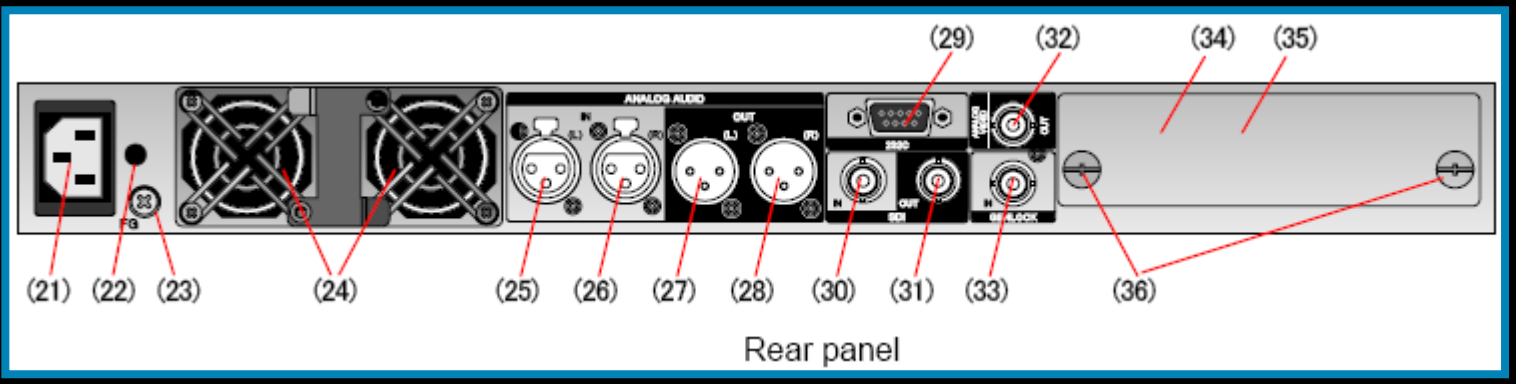


Front panel

Hardware Description and Specifications

Rear Panel

21. Power inlet connector (INPUT 100-240VAC)
22. AC cord clamp hole
23. FG terminal (FG)- Use for an FG connection to the device.
24. FAN - Maintenance-free FAN that cools the inside of the device.
25. Audio input (ANALOG AUDIO IN) (L), (R) - Balanced audio input terminal. (26)
26. Audio input (ANALOG AUDIO IN) (L), (R) - Balanced audio input terminal.
27. Audio output (ANALOG AUDIO OUT) (L), (R) - Balanced audio output terminal.
28. Audio output (ANALOG AUDIO OUT) (L), (R) - Balanced audio output terminal.
29. RS-232C port (232C) - RS-232C data communication port.
30. SDI video input (SDI IN) - Digital HD-SDI video input terminal. 75Ω unbalanced.
31. SDI video output (SDI OUT) - Digital HD-SDI video output terminal. 75Ω unbalanced.
32. Video output (ANALOG VIDEO OUT) - Analog video output terminal. 75Ω unbalanced.
33. Reference clock signal input (GENLOCK IN) - External clock signal input terminal. 75Ω unbalanced.
34. Optional card slot
35. Blank panel - Remove when the optional card is equipped.
36. Screws



Rear panel

D9094 Functional Features

Main Encoder

- HD
  - Profile
    - MP@L4
    - HP@L4
    - CSC422 (Proprietary)
  - Rate
    - 4 to 27 Mbps (38Mbps @4:2:2)
  - Resolution (59.94/50 Hz)
    - 1080i x [960, 1440, 1920]
    - 720p x [640, 960, 1280]
  - Encoding Control
    - Quality (IBBP) – 1.38s (ASI)
    - Motion (IBP) – 1.38s (ASI)
    - Low latency (IPPP) – 650ms*(ASI)
    - Low latency (PPPP) – 300ms(ASI)

Sub Encoder

- SD
  - Profile
    - MP@L3
    - HP@L3
  - Rate
    - 1.3 to 10Mbps
  - Resolution
    - 480i (59.94 Hz)
    - 576i (50 Hz)
  - Encoding Control
    - Quality (IBBP) – 1.38s (ASI)
    - Motion (IBP) – 1.38s (ASI)
    - Low latency (IPPP) – 650ms*(ASI)
    - Low latency (PPPP) – 300ms(ASI)

* TBC (still being tested)

D 9094 Functional Features

Main Encoder Audio

- Audio Encoding Formats
  - 4 stereo pairs selectable out of 8 embedded pairs input
  - MPEG-1 Layer-2
    - 128kbs, 256kbps, or 384kbps per pair
    - Stereo/Dual mono selectable
  - MPEG-2 AAC
    - 64kbps, 128kbps, 256kbps per pair
  - Uncompressed
    - 2,304kbps per pair

- Audio Pass-through
  - Pass thru (SMPTE302M)
    - 2,304kbps per pair
  - Pass thru AC-3
  - Sampling
    - 48kHz
  - Quantization
    - 16bit (Compressed)
    - 20bit (Uncompressed)

Registrujte se za Cisco Networkers
25-28. januar 2010. Barselona
28-31. mart 2010. Bahrein