Content-Adaptive Encoding Made Simple
1. Beamr was founded in 2009 expressly to develop content-adaptive technology.

2. 29 patents have been granted, 18 patents pending.

3. First commercial implementation was Beamr Video, shown at IBC in 2013 and shipped in 2014.

4. 2016 we acquired Vanguard Video to extend the application of a content-adaptive quality driven process into the encoder.
Content-Adaptive Encoding encodes each title using the “right” bitrate, based on the “needs” of the video.

➔ Animation and talking heads “need” less bits than sports and action movies.

➔ Within each title bitrate needs vary for each specific scene and even from frame to frame.
ABR (Adaptive BitRate) utilizes **fixed bitrates** per layer.

The ABR client selects the best bitrate ("layer") based on the user’s available bandwidth.

ABR adapts to **network conditions**, but not to the needs of the content.
WHY ABR IS NOT CONTENT-ADAPTIVE.

Using fixed bitrates for encoding different titles results in:

- Over-allocation of bits (inflated files)
- Under-allocation of bits (low video quality)
METHODS FOR CONTENT-ADAPTIVE ENCODING.

→ Manually: extremely time intensive

→ By Category: not all content is equal

→ By Title: Netflix approach, CPU intensive

→ By Frame: Beamr’s approach
MANUAL CONTENT-ADAPTIVE ENCODING

1. Encode each title using gradually increasing compression levels (typically with CRF).

2. When you notice a visible drop in quality, ignore the last encode, and use the bitrate resulting from the previous CRF to encode the title.

Pros:
- Simple method that does not require any special tools.
- Useful for low-volume content with high-value titles. E.g. Blu-ray

Cons:
- Very time consuming (expensive).
- Requires a human (not scaleable).
CATEGORY LEVEL CONTENT-ADAPTIVE ENCODING

(covered by Jan Ozer in his book “Video Encoding by the Numbers”)

1. Divide content into categories (manually or through metadata). Select 3-5 representative titles in each category, and manually encode each one of them.

2. Calculate the average bitrate of the representative titles, and use this bitrate for encoding all titles in the category. Verify PSNR and Visual Quality while encoding the titles.

Pros:
• Simple process that can be implemented by any video producer using off-the-shelf tools.

Cons:
• Does not take into account changes in content complexity between titles in the same category. Does not take into account changes in content complexity between scenes.
• Requires manual QC (visual inspection)
TITLE LEVEL CONTENT-ADAPTIVEENCODING

(presented by Netflix in “Per-Title Encode Optimization” - Netflix Tech Blog, Dec 14th, 2015)
Pros:
• Improves quality and reduces bitrates vs. fixed ABR ladder, e.g. Apple TN2224.
• Outside of Beamr, this approach is the closest any solution has come in commercial deployment to being content-adaptive.

Cons:
• Does not take into account changes in content complexity between scenes.
  
  This was addressed by Netflix proposing a method of complexity-based encoding in IEEE ICIP 2016 conference. An additional pass is performed per chunk in an attempt to reduce the bitrate using the CRF of the title (capping that bitrate at the max bitrate of the title).
• Very high computational complexity due to the need to encode each title numerous times combined with the high complexity of the VMAF quality measure itself.
FRAME LEVEL QUALITY DRIVEN CONTENT-ADAPTIVE

- **High reliability**: Has a high correlation with the Human Visual System.

- **Codec suitability**: Tuned to detect specific artifacts created by the encoding process, not general deformations or bit errors.

- **Image adaptable**: Able to detect with a high degree of accuracy specific features and areas in the image, and adapt the quality measure accordingly.

- **Low complexity**: Supports real-time operation.
**Video Encoder**
Encodes input frame into candidate output frame using compression parameters provided by system controller.

**System Controller**
Controls iterative process of frame recompression.

**Quality Measure Analyzer**
Compares quality of candidate output frame with quality of input frame by computing value using patented perceptual quality measure.

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**Input Frame**

**Video Encoder**

**Compression Level**

**System Controller**

**Quality Indication**

**Quality Measure Analyzer**

**Output Frame**

**Candidate Output Frame**

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**BEAMR FRAME LEVEL CONTENT-ADAPTIVE ENCODING**

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BEAMR FRAME LEVEL BITRATE REDUCTION EXAMPLE

BANDWIDTH SAVING

NO BANDWIDTH SAVING

AVERAGE BITRATE 3510 kbps → 2584 kbps
PEAK BITRATE 7593 kbps → 5598 kbps
## BEAMR FRAME LEVEL H.264 ACROSS DIFFERENT GENRES

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<tr>
<th>Title</th>
<th>180p 0.2Mbps</th>
<th>180p 0.3Mbps</th>
<th>288p 0.5Mbps</th>
<th>360p 0.75Mbps</th>
<th>432p 1.2Mbps</th>
<th>720p 2Mbps</th>
<th>1080p 3.5Mbps</th>
<th>1080p 6Mbps</th>
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<td>23%</td>
<td>16%</td>
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</table>
VBR

CABR offers 50% savings over VBR

CABR
➔ Fixed ABR adapts to network conditions, not content.
➔ Content-adaptive encoding ensures optimized bitrate & quality.
➔ Manual methods are not scaleable.
➔ Per-title methods are too CPU intensive.
➔ Frame level content-adaptive encoding when combined with a perceptual quality measure provides the best bitrate/quality tradeoff.
➔ Beamr is the first to implement a content-adaptive rate-control function in the Beamr 5x HEVC software encoder SDK.
Learn more at beamr.com