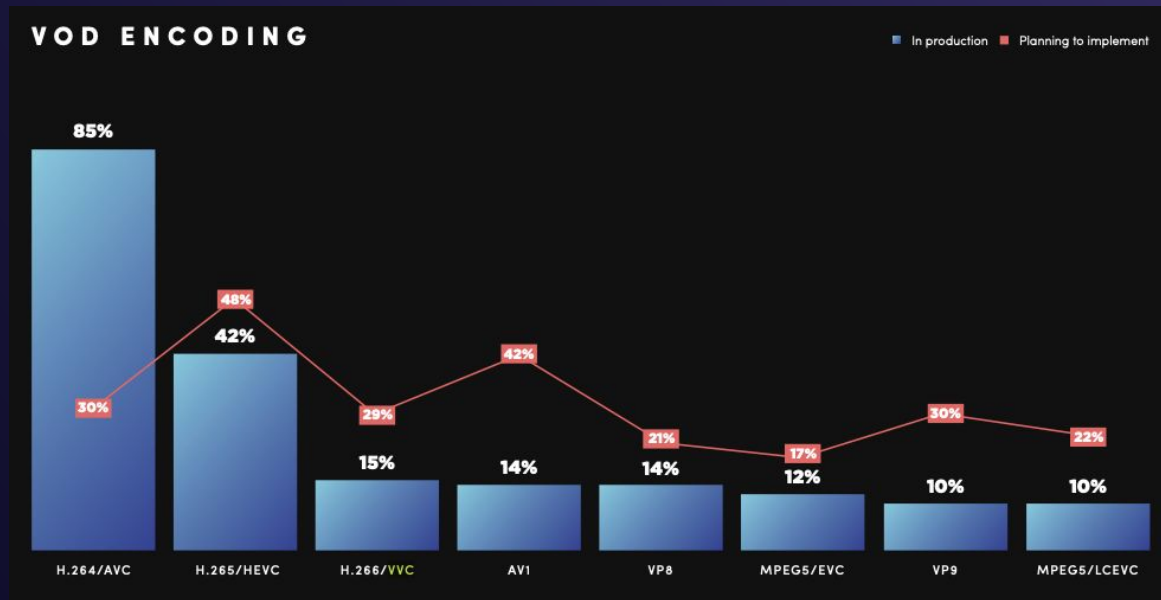


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# Encoding VVC for VOD

# Market deployment insight

- Bitmovin's Video Developer Report
- Survey June - September 2022
- Published December 2022
- 424 respondents from 80+ countries



# VVC highlights, comparing to HEVC

- An evolution, not a revolution but versatile indeed!
- Open GOP resolution-adaptive multi-rate streaming (additional ~10% gain)
- Many features are built in to address broad range of applications:
  - High dynamic range (HDR), Wide colour gamut (WCG), Film Grain Synthesis (FGS)
  - UHD 8K and VR/360-degree immersive video
  - Bitstream extraction and merging, temporal scalability, gradual decoder refresh
  - Multi-layer coding for multiview, alpha maps, depth maps, and spatial and quality scalability
- Bytedance recently shared results from their BVC encoder
  - 53% bitrate savings and 10% faster vs x265 (3.4)
  - 4% bitrate savings and ~1000x faster vs HEVC HM (17.0) reference

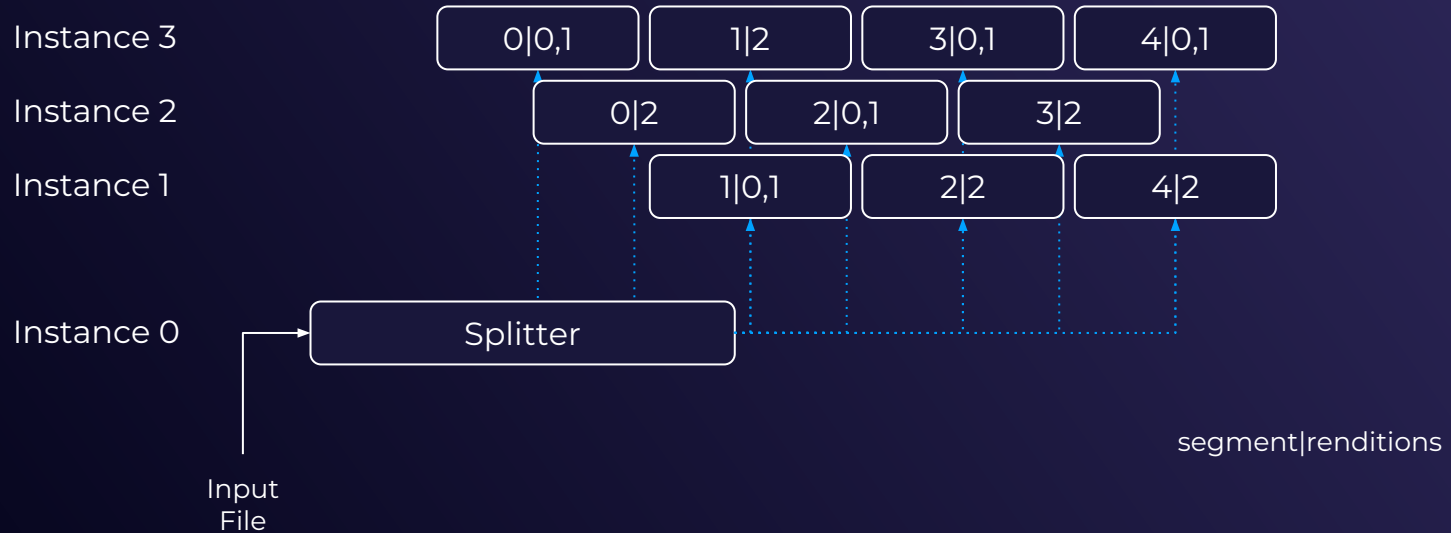
# Available VOD encoding software

- Open-source
  - JVCET **VVC Test Model (VTM)** reference encoder (and decoder) codebase
  - Fraunhofer **VVenC** real-world encoder (1.8.0 latest) ... and VVdeC decoder
  - Friedrich–Alexander University Erlangen–Nürnberg **bitstream analyser** (as an add-on for the VTM decoder)
- Commercial
  - MainConcept **SDKs and plugins for VVC** encoding (incl live)
  - Bytedance **BVC** encoder with many/most VVC features implemented
  - Tencent **RT-ONE** encoder available in Tencent Cloud
  - Alibaba **Ali266** encoder available in Alibaba Cloud
  - Ateme **TITAN** family of encoding products with real-world (live) trials
  - Bitmovin **VOD Encoder** cloud-native/agnostic integration of VVenC
- Streaming services
  - **MX Player** and **MX TakaTak** in India deployed to 20% of customer base

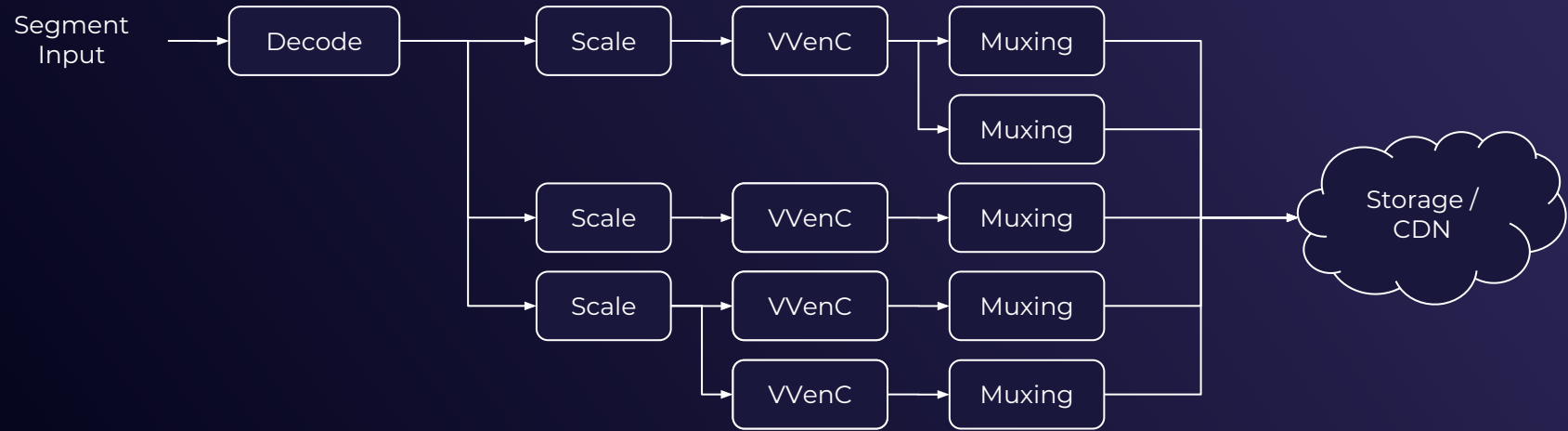
# Bitmovin integration summary

- Close collaboration with Fraunhofer HHI in Berlin
- Experimented with VTM reference early on (details in appendix)
- Integrated VVenC open-source project (and VVdeC for playback)
- Making contributions back to improve C-style interface
- 40% BD-rate gain, and 50% observed in subjective tests
- Compute needs
  - 8x more vs AVC
  - 4x more vs HEVC
  - 2x more vs AV1
- Internal API for now while we tune and optimize
  - Reduce compute needs to ~1x or less vs HEVC
  - Integrate more features

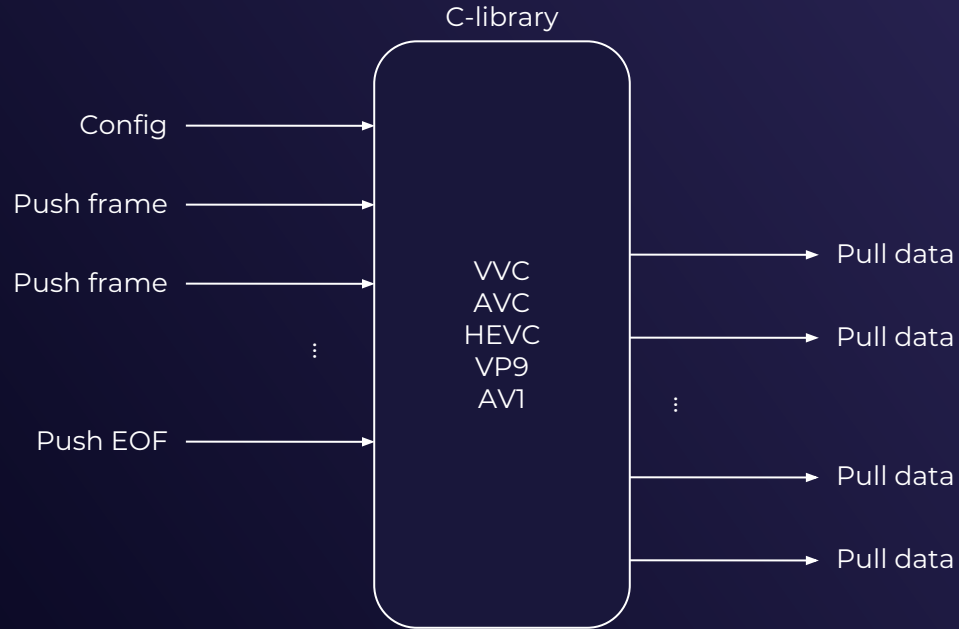
# Bitmovin cloud encoding - split and stitch



# Bitmovin cloud encoding - a job



# Bitmovin cloud encoding - encoder interface



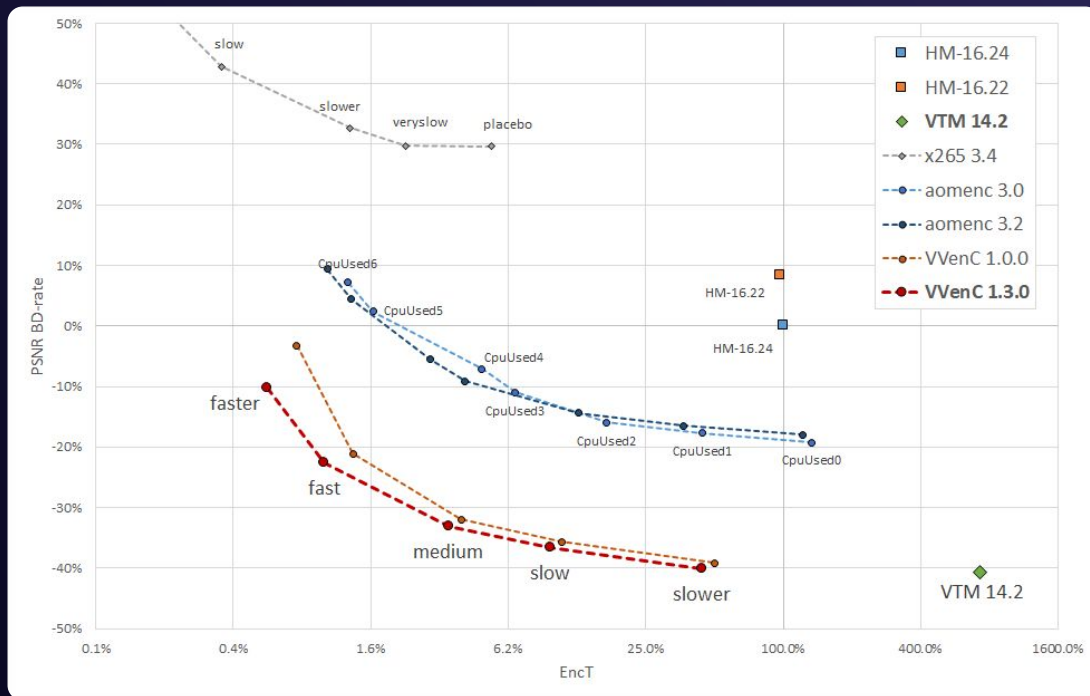


# VVC encoding in the cloud - results

- It basically **Just Works!**
- **VVenC** (*medium*) vs **x265** (*slow*)
  - Around **40%** bitrate reduction for HD content
  - Reduced convex hull-complexity
  - Prediction continuity even for progressive streaming
- Current limitations
  - Higher memory consumption
    - Still within limits of usual cloud instances
  - Limited flexibility with segment duration

# VVC compared to other codecs

Better quality  
↓



←  
Faster

# VVC optimal ladder observations

| Reference | x256 opt.  | VVenC opt.  | x265 opt.  | x265 opt.   |
|-----------|------------|-------------|------------|-------------|
| Test      | VVenC opt. | VVenC 1080p | x256 1080p | VVenC 1080p |
| MS-SSIM*  | -39.84%    | 2.73%       | 16.16%     | -37.86%     |
| XPSNR*    | -52.20%    | 1.11%       | 12.35%     | -51.00%     |

\*Fraunhofer HHI test-set average over 7 HD SDR sequences

# Bitmovin cloud cost

| AVC | HEVC | AV1 | VVC |
|-----|------|-----|-----|
| 1.0 | 2.2  | 4.5 | 8.7 |

2-pass Encoding

5 Renditions

- 1080p 6Mbit
- 720p 3Mbit
- 540p 1.8Mbit
- 234p 416kbps

Bitrate factors

- AVC (1), HEVC (0.67), AV1 (0.55), VVC (0.4)



# What's next?

- Research paper for IBC 2023
  - Focus on adaptive open GOP referencing with RPR
  - Closed GOP means every segment is decoded independently
  - Open GOP requires previous segment to be available
  - VVC allows this thanks to previous reference frames
  - Benefit is gradual transitions between scenes and addtl bitrate savings
- Expectations
  - Incremental ~10% BD-rate gain
  - Basis for per-shot/scene encoding
  - VOD and live, but focus on VOD

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# Packaging VVC for VOD

# Packaging for D2C distribution

Very similar to AVC and HEVC, with some VVC-specific extensions

- ISO-BMFF (aka MP4) and MPEG-2 TS defined
- AAC and MPEG-H audio codecs
- DASH streaming format (and theoretically, HLS)
- Same captions and subtitles
- Same encryption and DRM options
- Open GOP consideration
  - Could mean different segment sizes because moving frames between segments but should be the same on average



A person's silhouette stands on a dark, silhouetted hill or ridge, looking up at a vast, starry night sky. The Milky Way galaxy is visible, stretching across the frame from the bottom left towards the top right, with a vibrant pinkish-purple glow in its central band. The sky is filled with countless stars, and the overall color palette transitions from deep blue and black at the edges to a warm, golden-yellow near the horizon where the person stands.

# Thank you.