On MCTS Tile Merger for CDN-based Viewport-dependent 360 Video Tiled Streaming

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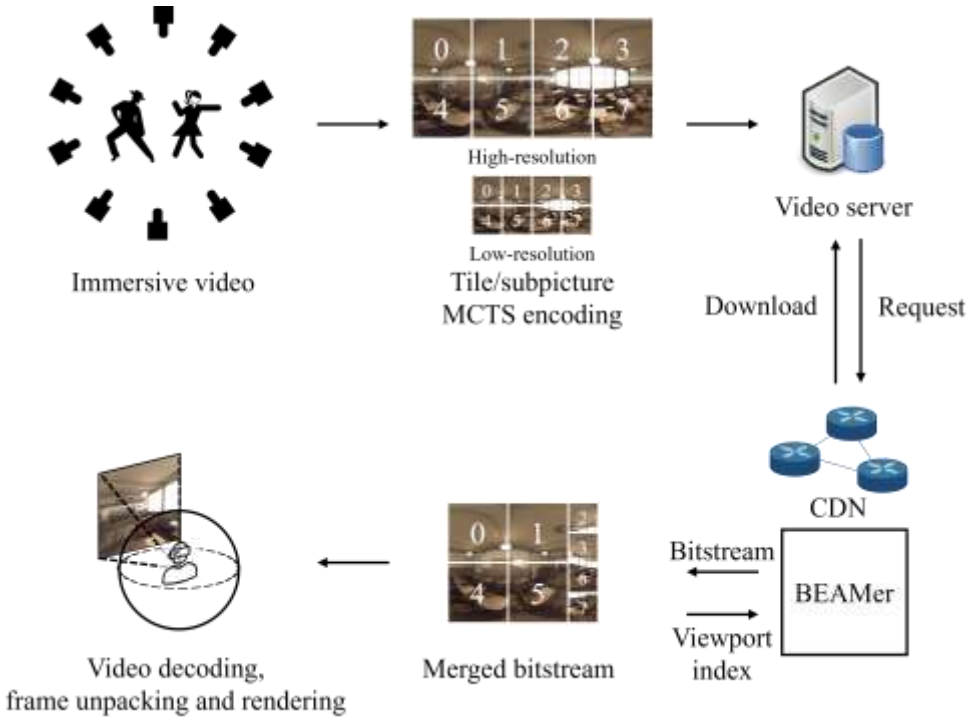
360 Video Tiled Streaming

- High resolution and framerate for high-quality 360 video streaming
  - high bandwidth, high computational complexity
- Tiled streaming based on MCTS for viewport-dependent streaming
  - Bitstream extractor and merger (BEAMer) in CDN
  - Distributed computing for flexible device-adaptive streaming



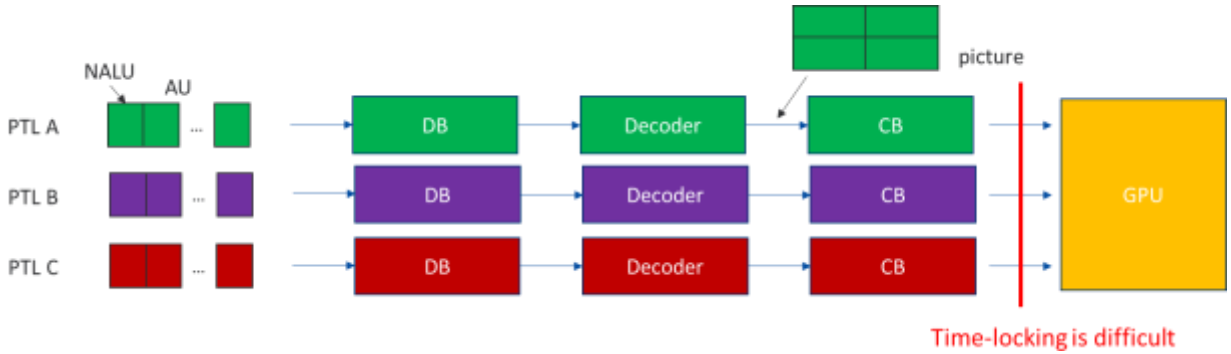
Immersive 360 video tiled streaming system

Requirement	details
pixels/degree	40 pix/deg
video resolution	11520 × 6480
framerate	90 fps

Requirements for high quality VR
Source:Technicolor, Oct. 2016 (m39532, MPEG 116th Meeting)

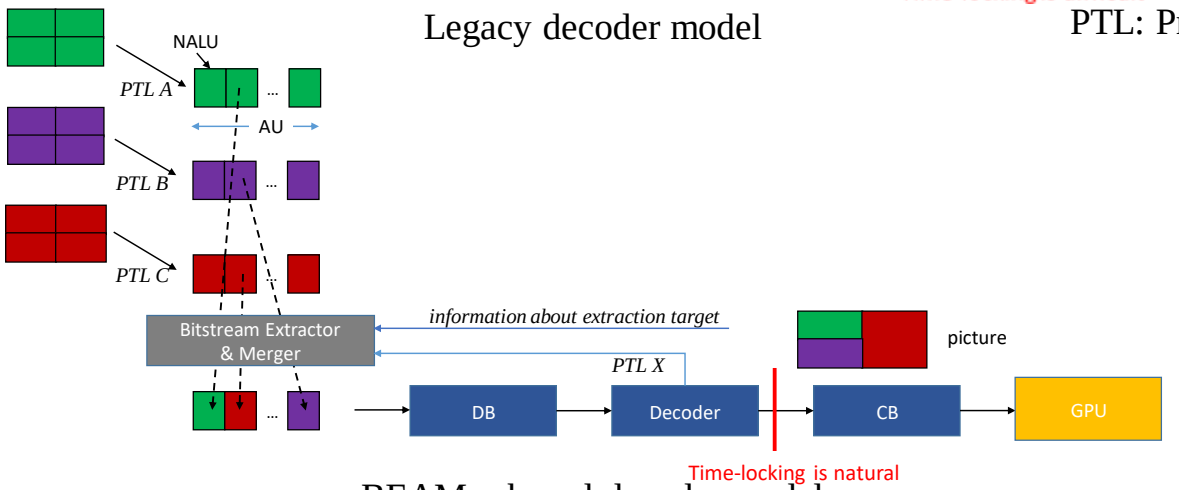
Background

- MPEG System group proposed BEAMer to:
  - Prevent waste of decoding resources (low-quality pictures which are not rendered)
  - Time consumption because of several bitstreams



Legacy decoder model

PTL: Profile/Tier/Level

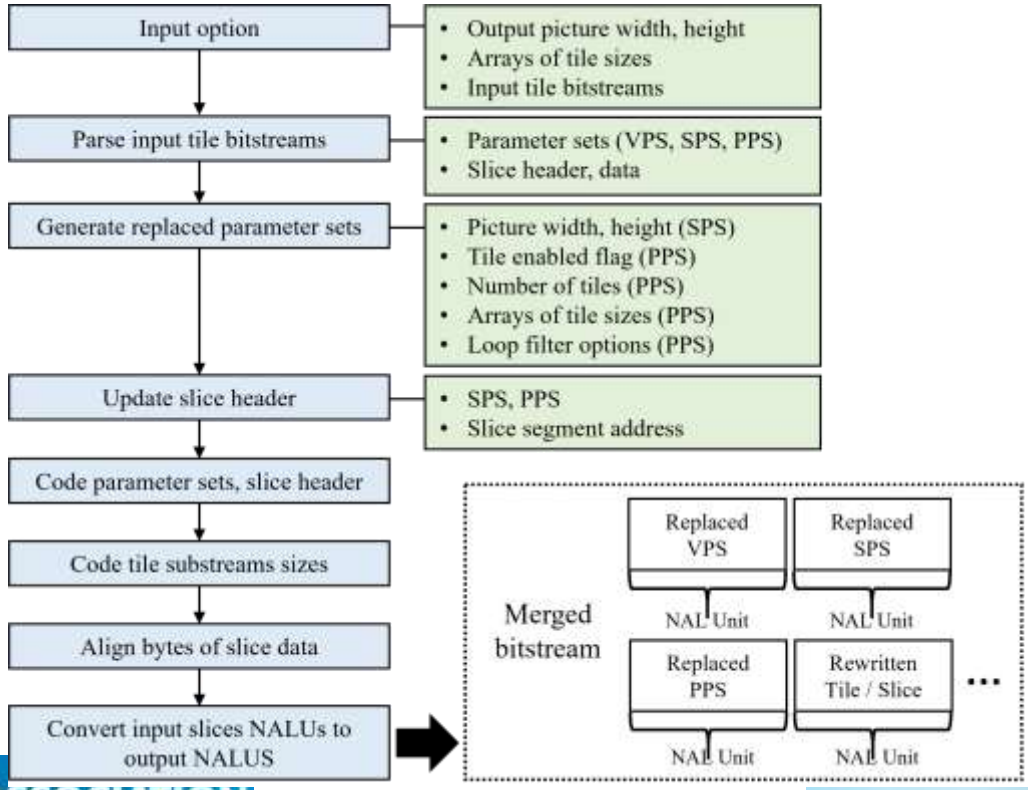


BEAMer-based decoder model

Source: ISO/IEC SC29 WG11, Thoughts on Immersive Media Decoding Interface for VVC, 126th meeting of ISO/IEC SC29 WG11, n18438, 2019.

Implementation of Tile Merger

- In HEVC test model (HM) 16.20, a tile extraction SW is included
  - Tile merging SW is not included
- Used low-level entropy coding objects to implement fast merging
  - HM extractor uses high-level objects -> slower
- HEVC and VVC-compliant versatile MCTS merging
  - Mixed quality, mixed resolution tile/subpicture merging is available



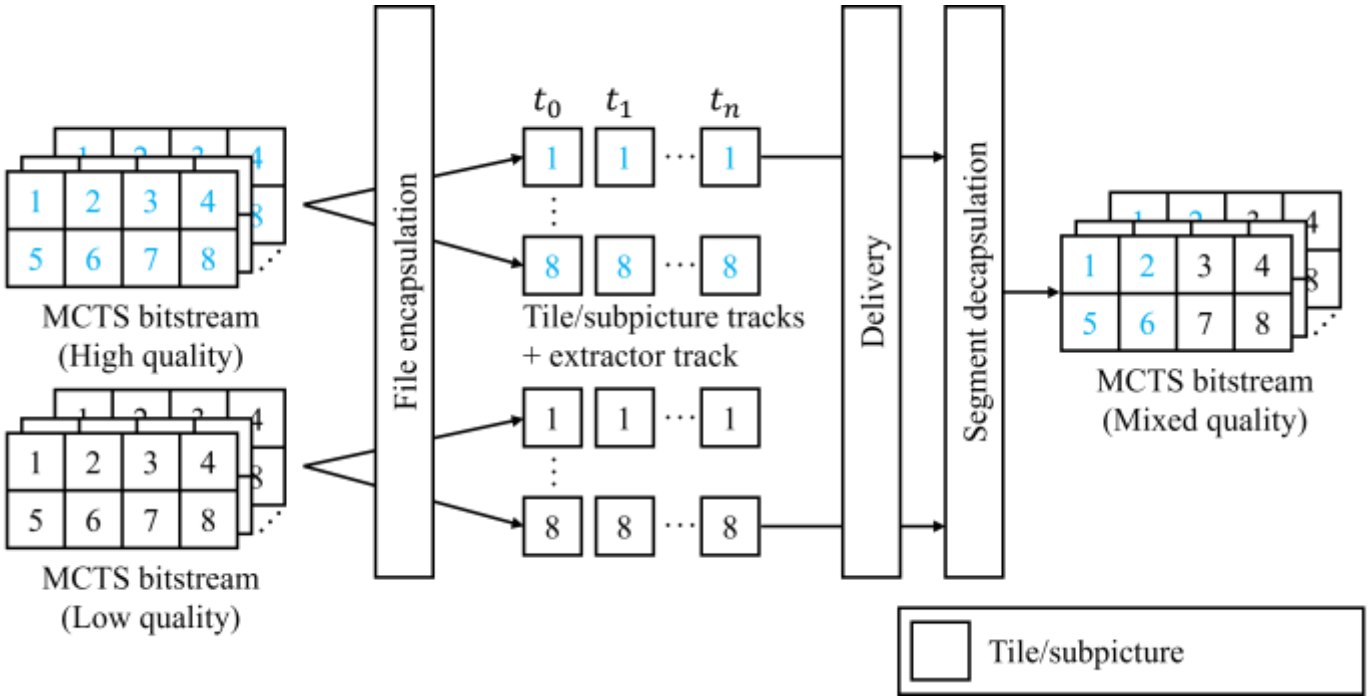
System architecture of tile merger

Mixed Quality Tiled Streaming

- Tiles/subpictures are divided in compressed domain using MCTS
- High- and low-quality MCTS bitstreams at the server-side
- Tile/subpicture QP modification for mixed quality merging

$$SliceQPDelta = PPS \rightarrow QP() - initQPMinus26 + 26$$

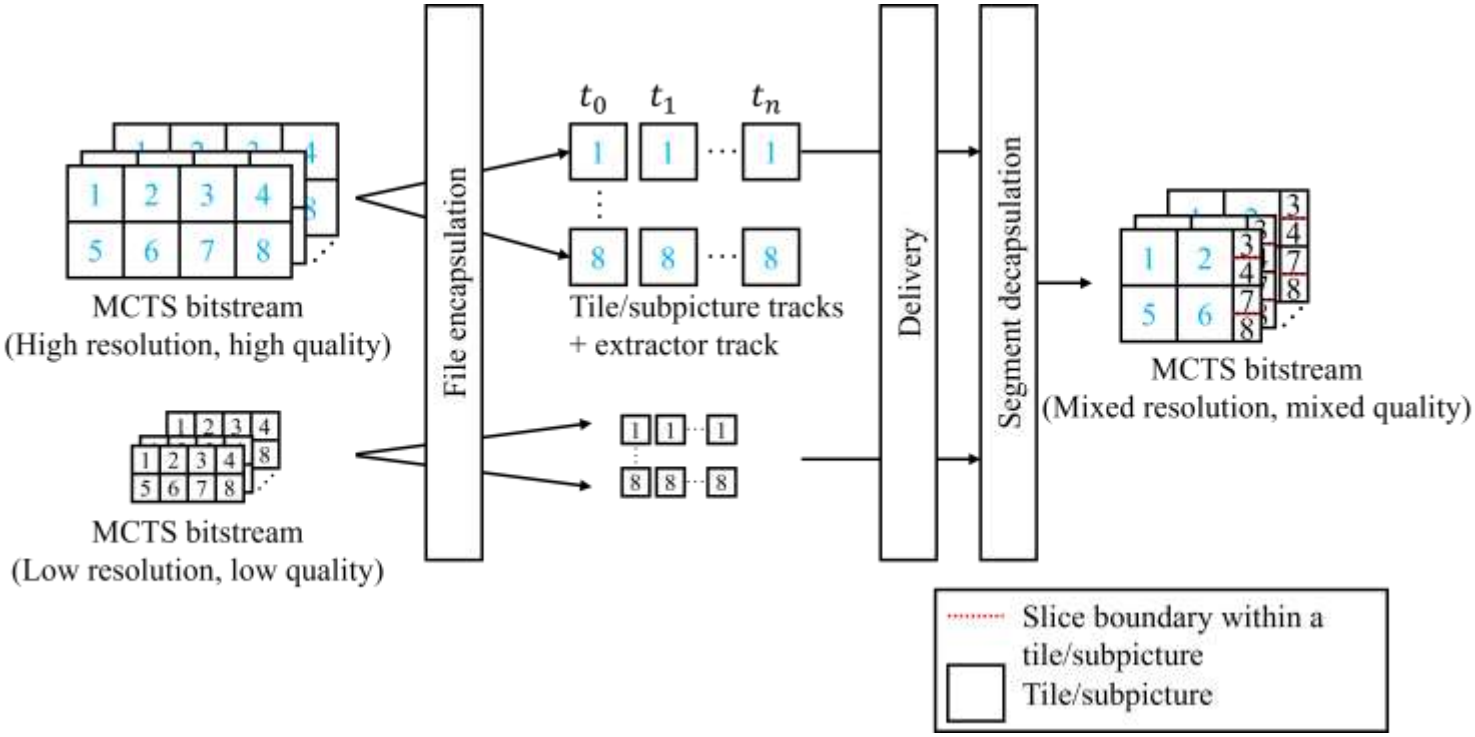
$$SliceQP = SliceQPDelta + 26$$



Example of mixed-quality viewport-dependent 360-degree video tiled streaming

Mixed Quality & Resolution Tiled Streaming

- Tiles/subpictures are divided in compressed domain using MCTS
- Mixed-quality and mixed-resolution MCTS bitstreams at the server-side
- HEVC and VVC-compliant versatile MCTS merging
  - Multiple slices aligned vertically in one tile/subpicture
  - Mixed quality, mixed resolution tile/subpicture merging is available



Example of mixed-quality and mixed-resolution viewport-dependent 360-degree video tiled streaming

Experimental Results

- HM 16.20 for encoding, ffmpeg git-2020-03-28-3362330 for decoding
- Intel i5-8250U (4 cores) and 8GB memory on the experimental device
- In merging, half of the tiles were HQ, the others were LQ
  - Quantization parameter (QP) 22 for HQ, 37 for LQ
  - Resolution 4096 × 2048 for HQ, 2048 × 1024 (down-sampled) for LQ
- Mixed quality & resolution saved 37.12% pixel rate and merging/decoding time

Method	Tiling	Resolution	No. of merged tiles	QP	Merging time (s)	Decoding time (s)
Anchor	-	4096 × 2048	-	22	-	3.014
Anchor	-	4096 × 2048	-	37	-	2.543
Mixed quality	2 × 4	4096 × 2048	8	22, 37	0.388	2.743
Mixed quality	4 × 8	4096 × 2048	32	22, 37	0.392	2.926
Mixed quality, mixed resolution	2 × 4	2560 × 2048	8	22, 37	0.386	2.048

Merging, decoding performances of mixed quality, mixed quality & resolution tiled streaming

Experimental Results (-Cont'd)

- Decoding by HM and ffmpeg without any problems
- At the tile boundaries, no visual errors were observed (successful merging)

Decoding example of mixed quality & resolution tiled streaming

Conclusion

- Motivation
  - High BW & computing time for 360-degree video streaming: tiled streaming can be used
  - Bitstream extractor and merger (BEAMer) in MPEG for:
    - ➢ Preventing the waste of decoding resources including time consumption
- Proposed Methods and Insights
  - HEVC bitstream merger for mixed quality & resolution tiled streaming
  - Pixel rate, merging time, decoding time savings compared to the anchor
  - CDN-based system architecture for flexible client-adaptive streaming
- Future Work
  - Experiments on several tiling scenarios will be conducted