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Complexity Reduction and Real Time Implementations of the Versatile Video Coding Standard

Complexity Analysis of VVC Intra Prediction

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Outline

- Introduction
- Related Works
- VVC Intra Prediction
- Experiments and Analysis
- Conclusions

Introduction

- Demand for video content is increasing
- Video resolution is continually increasing
  - HD -> Full HD -> 4K UHD and beyond…
- Immersive content such as HDR and 360-degree video
- Better compression performance is required

Introduction

- Joint Video Experts Team (JVET)
  - Collaboration of MPEG and VCEG
- Specify a new video coding technology
  - Compression performance much higher than the previous standard
    - Target -> 50% better than HEVC
    - Enable transmission of UHD video with bitrate near HD video
  - Versatility for effective use in the emerging applications
    - Screen Content Coding (SCC)
    - HDR -> high bit depth -> 10/12 bits
    - 360-degree video

Introduction

- Versatile Video Coding (VVC) standard was finished in July 2020
- VVC has adopted a lot of novel techniques
  - Larger block size
  - Flexible block partitioning -> Multi-type tree (MTT)
  - Dual tree -> separate MTT coding tree for chroma
  - Higher number of angular intra prediction modes, among others…
- Computational complexity of VVC is significantly increased

Related Works

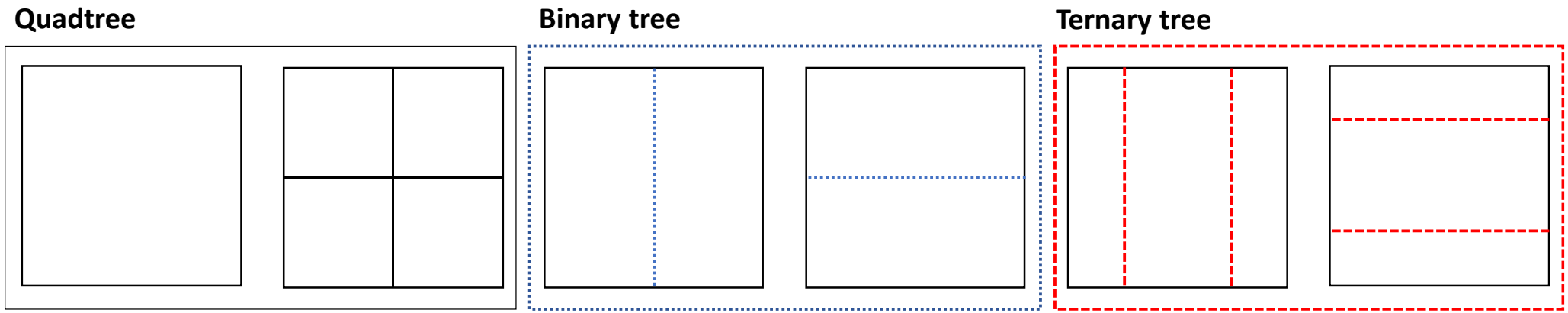
- Complexity analyzes are needed to identify the most time-consuming modules
  - Topiwala et al. [15] presented a subjective analysis and compared the bitrate compression performance of VVC, HEVC, AV1, and EVC
  - Tissier et al. [18] analyzed the upper limits of complexity reduction for block partitioning, intra prediction, and transform selection
- These works do not perform a detailed study for identifying the complexity of each VVC intra coding tool

[15] P. Topiwala, M. Krishnan, W. Dai, "Performance comparison of VVC, AV1, and HEVC on 8-bit and 10-bit content," SPIE Applications of Digital Image Processing XLI, v. 10752, pp. 305-314, 2018. DOI: 10.1117/12.2322024

[18] A. Tissier et al., "Complexity Reduction Opportunities in the Future VVC Intra Encoder," IEEE 21st International Workshop on Multimedia Signal Processing (MMSP), 2019, pp. 1-6. DOI: 10.1109/MMSP.2019.8901754

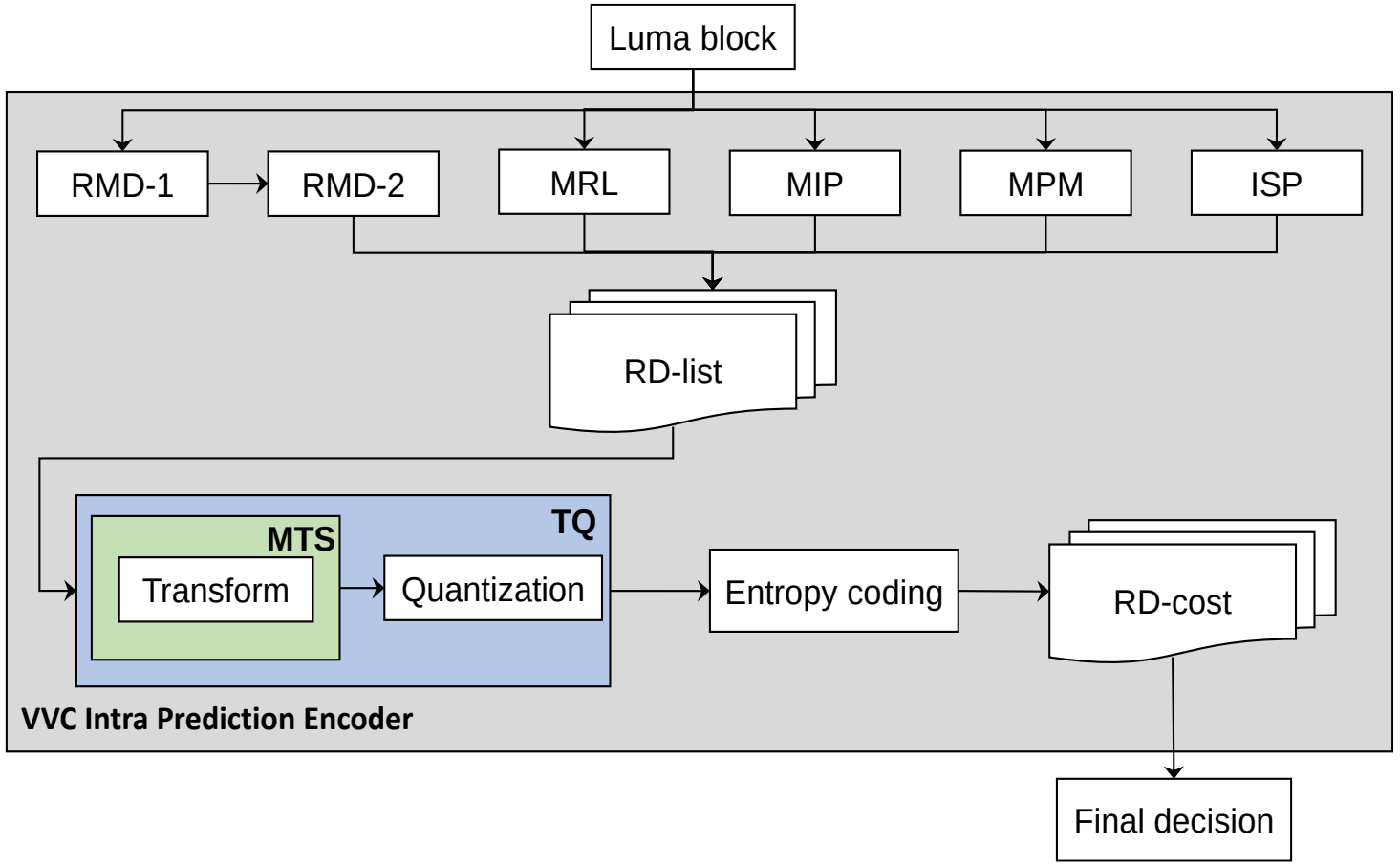
VVC Intra Prediction

- QTMT structure -> more flexible block partition types
  - Adapt the features of several texture patterns
- Removes the separation of CU, PU, and TU concepts
- VVC intra prediction
  - Square and rectangular shapes -> ranging from 4x4 to 64x64



VVC Intra Prediction

- Intra coding flow



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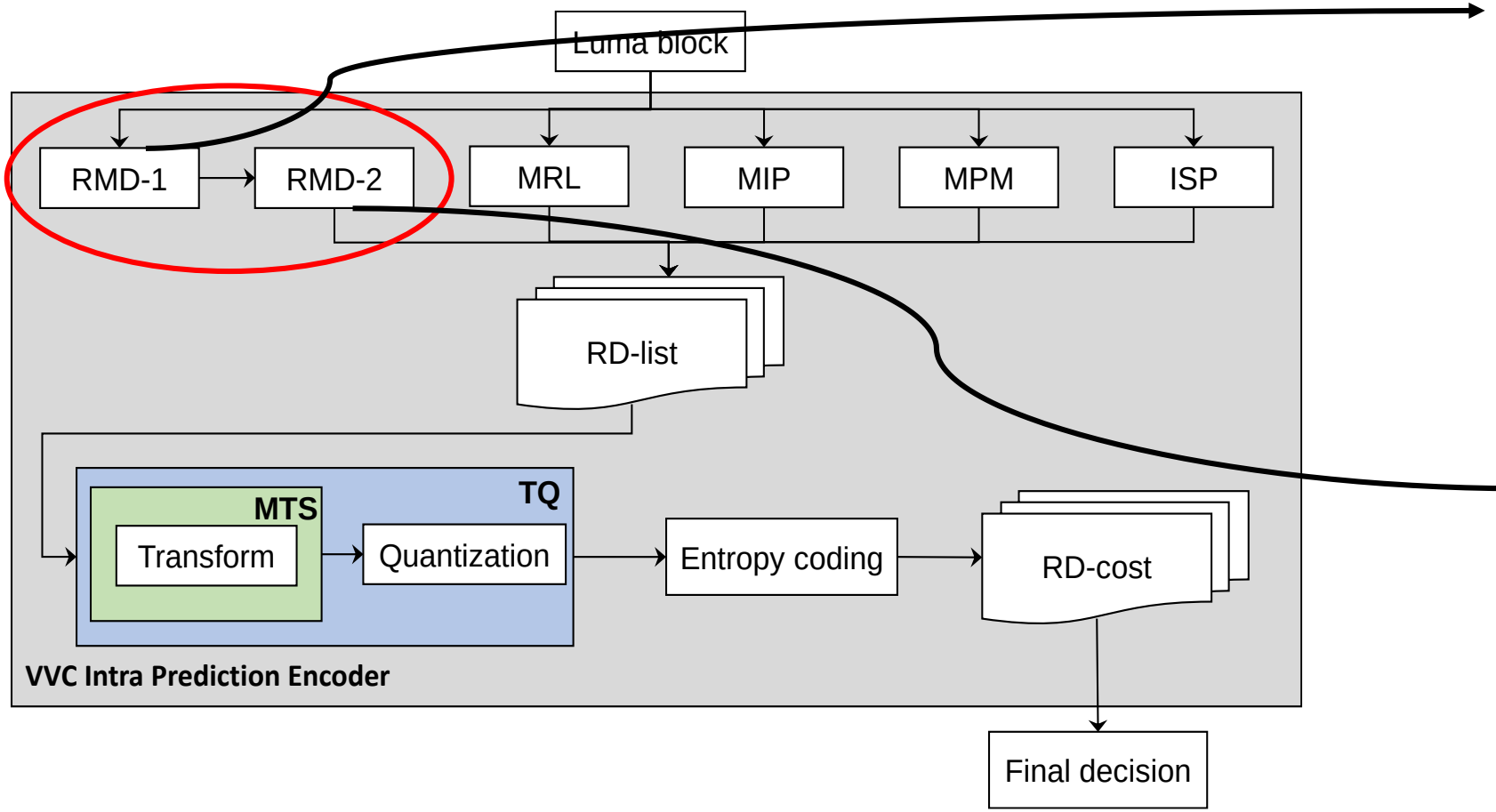

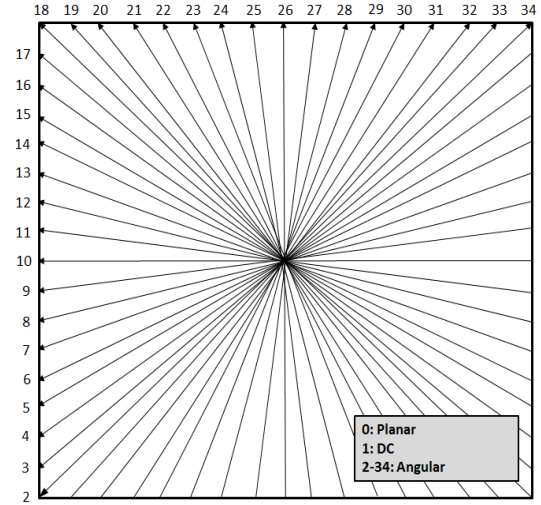

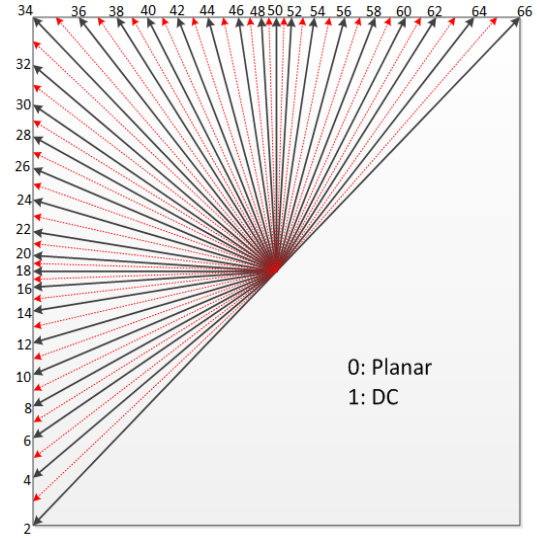

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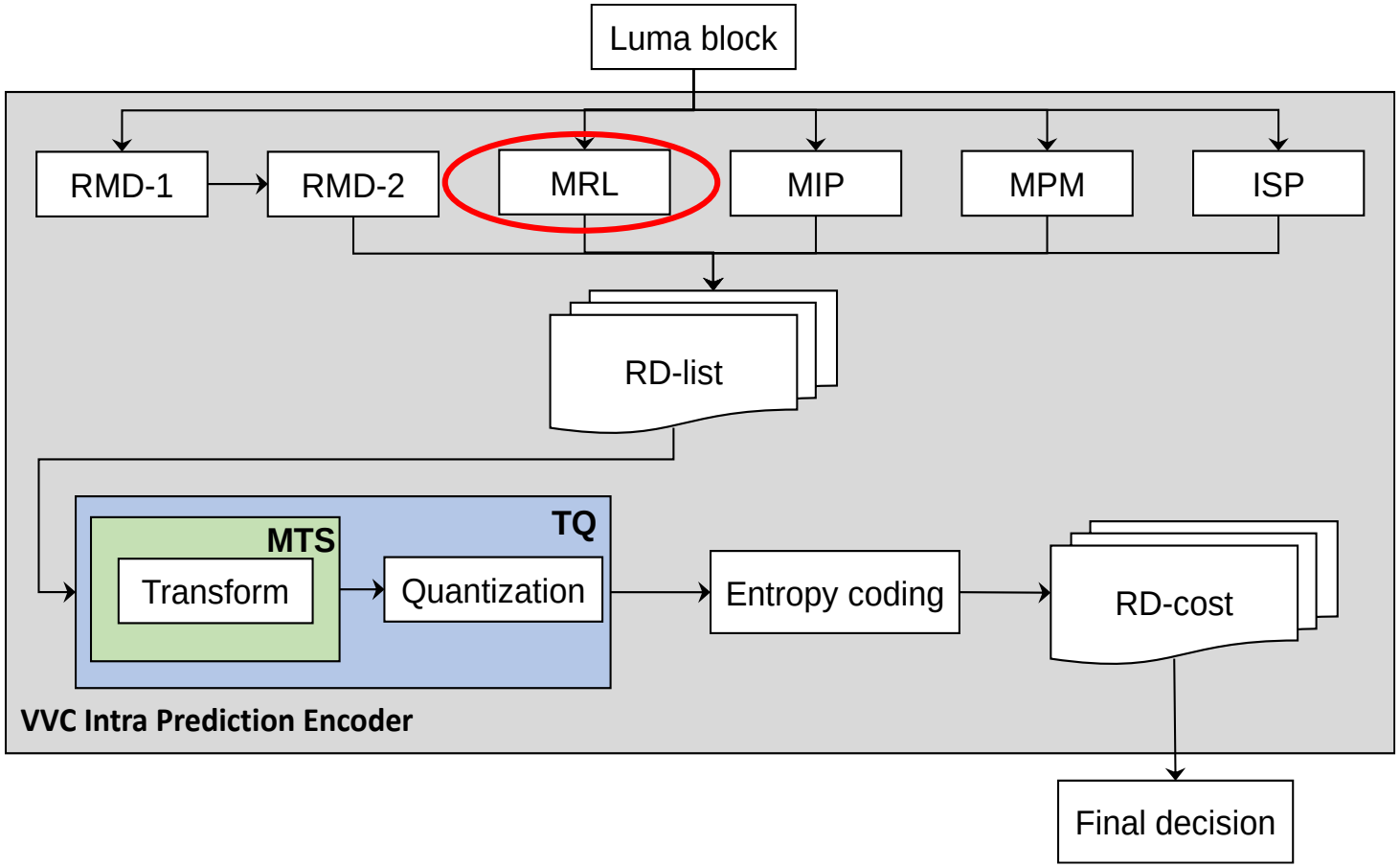

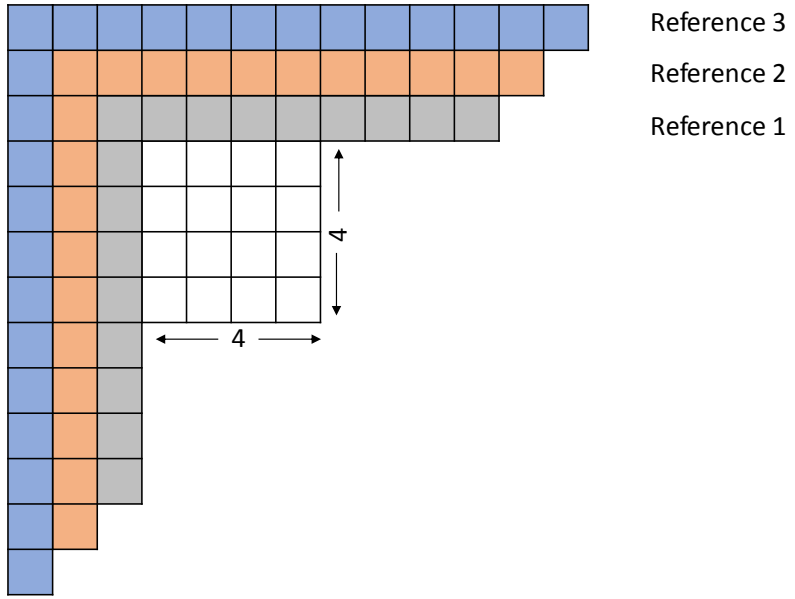

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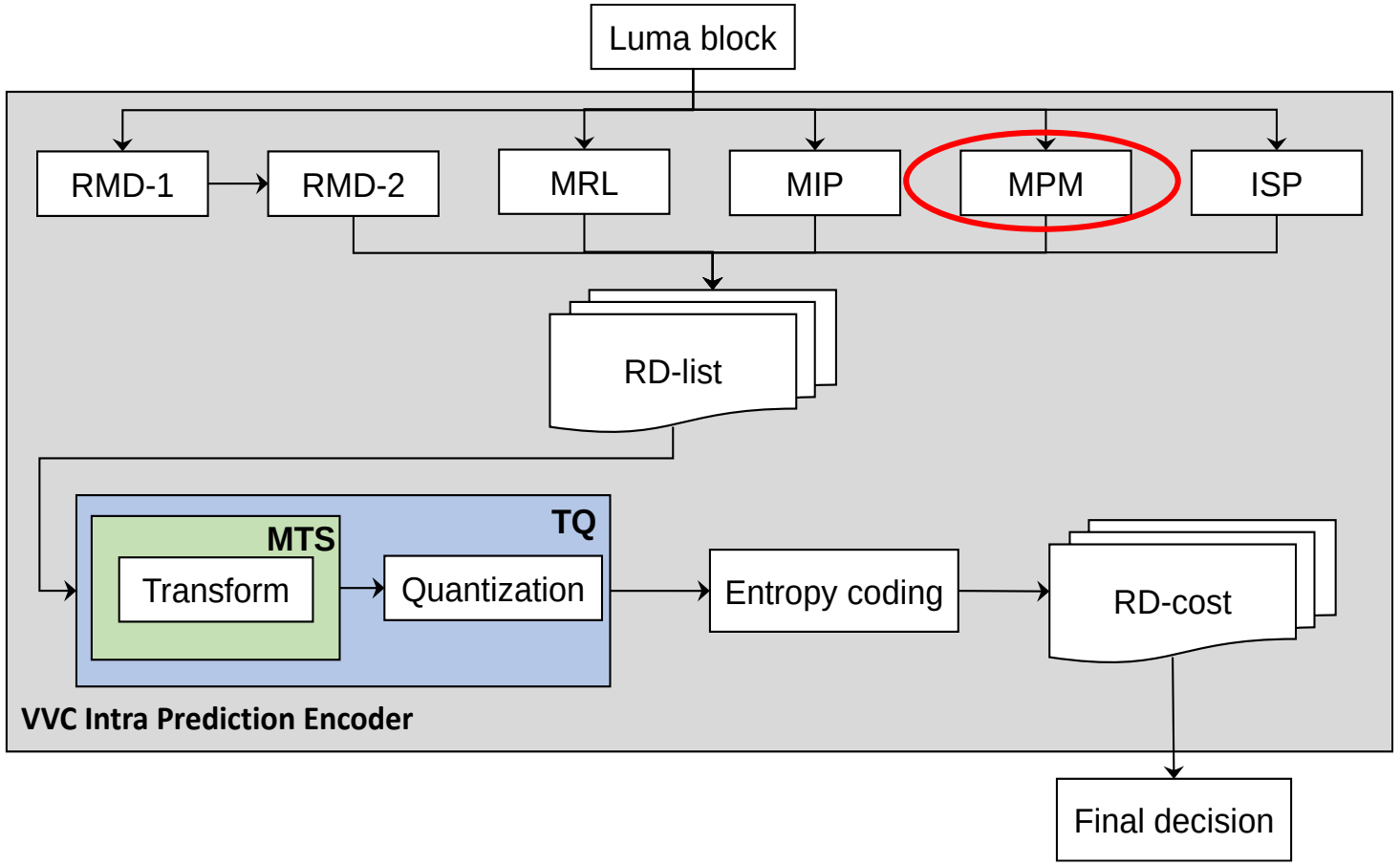

VVC Intra Prediction

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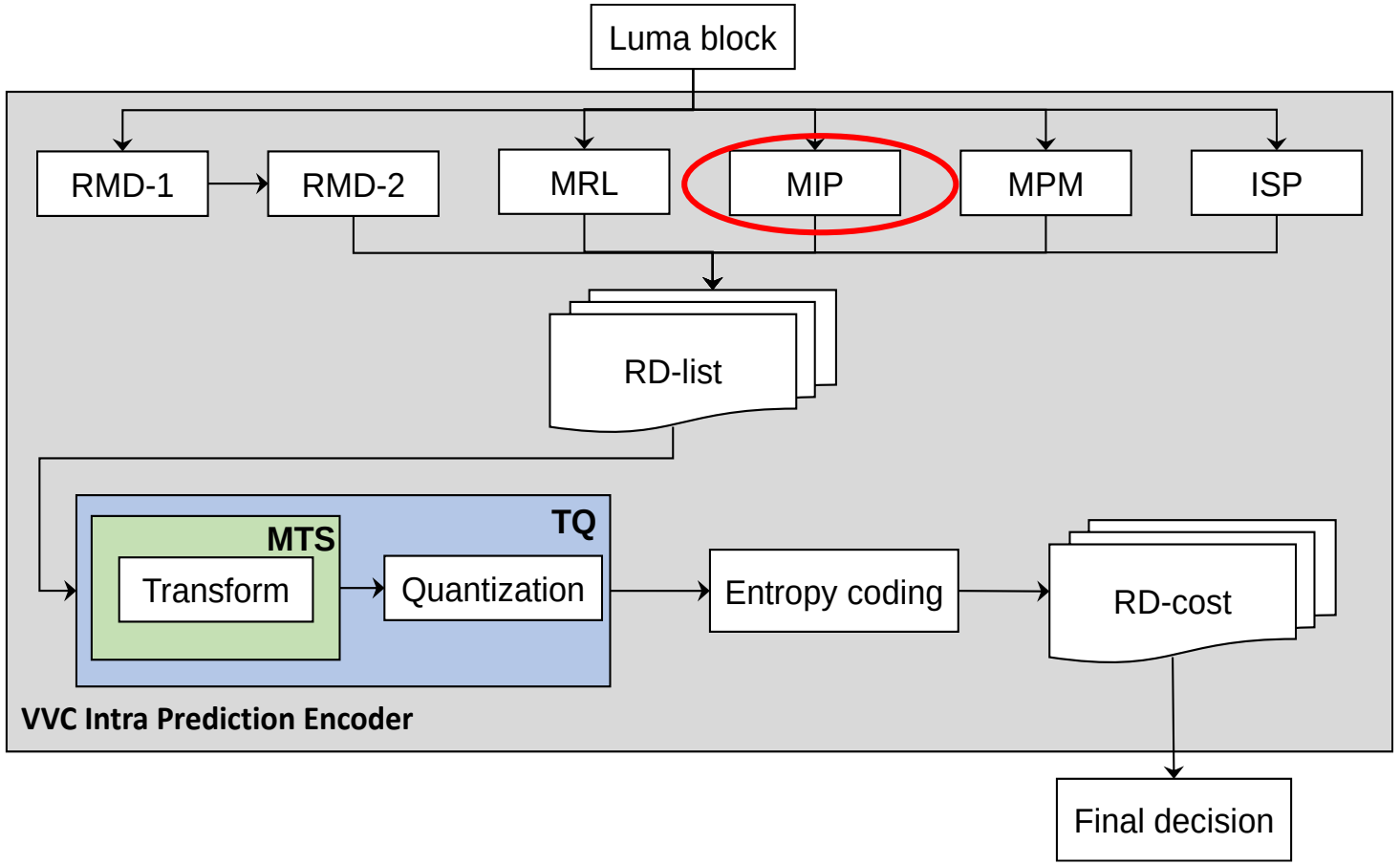

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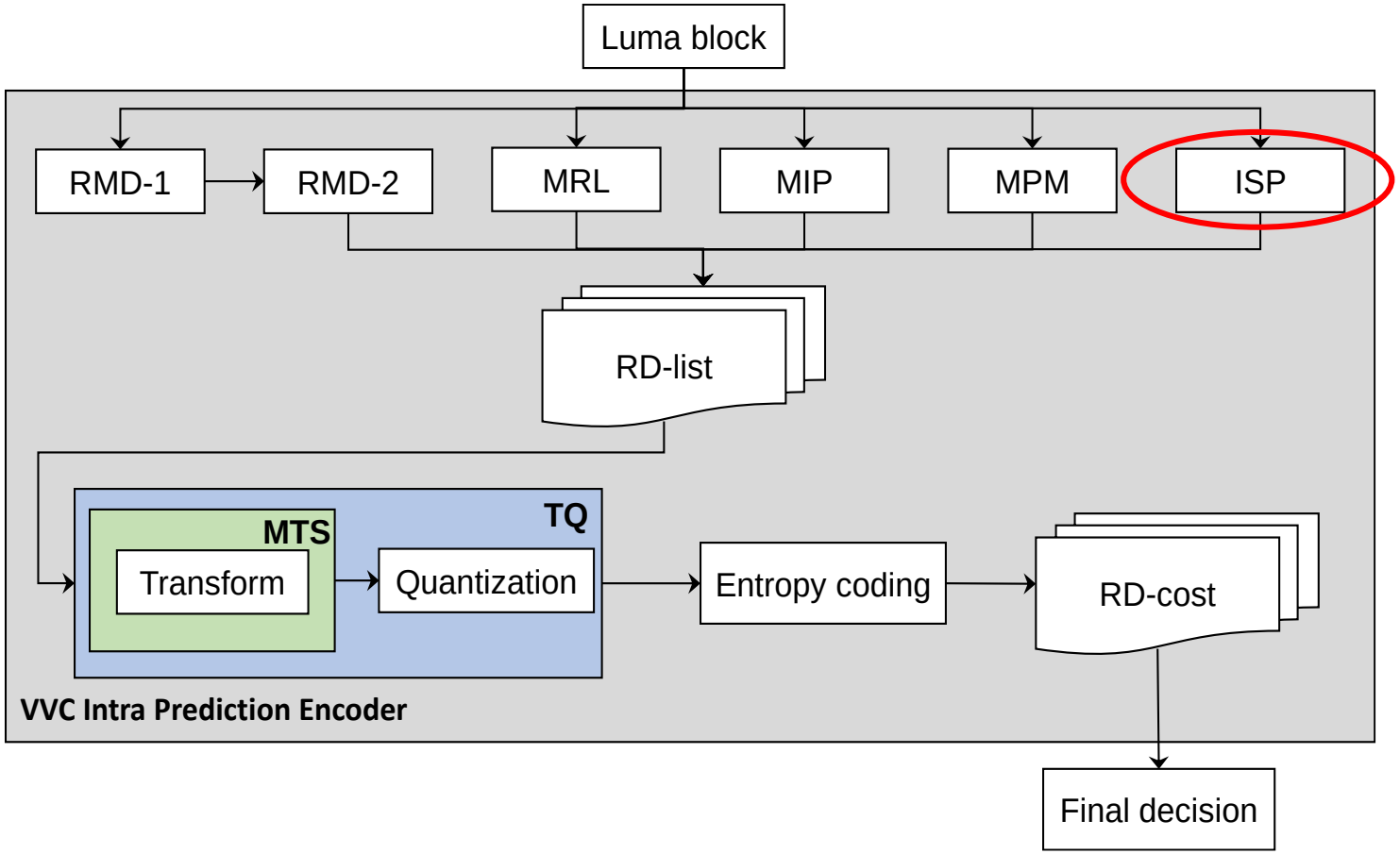

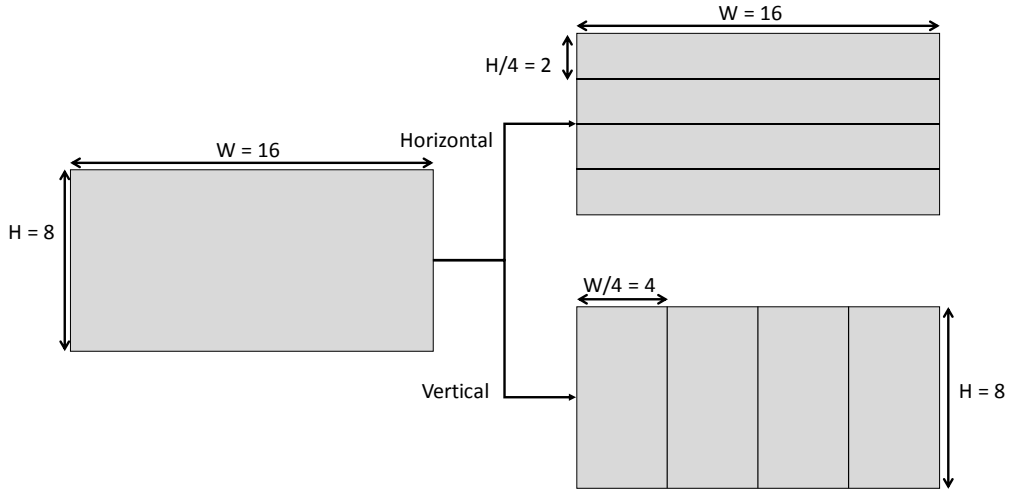

VVC Intra Prediction

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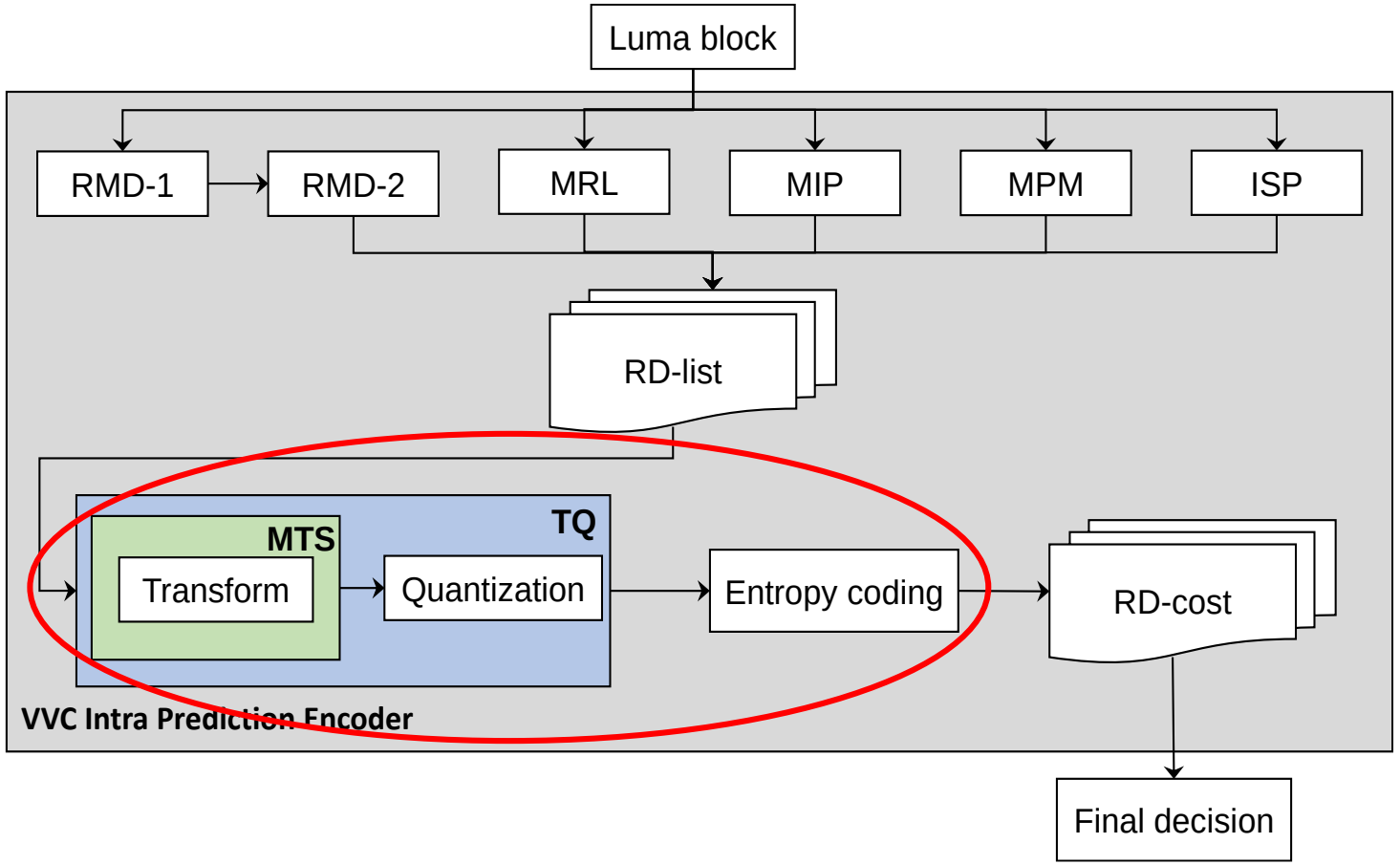

VVC Intra Prediction

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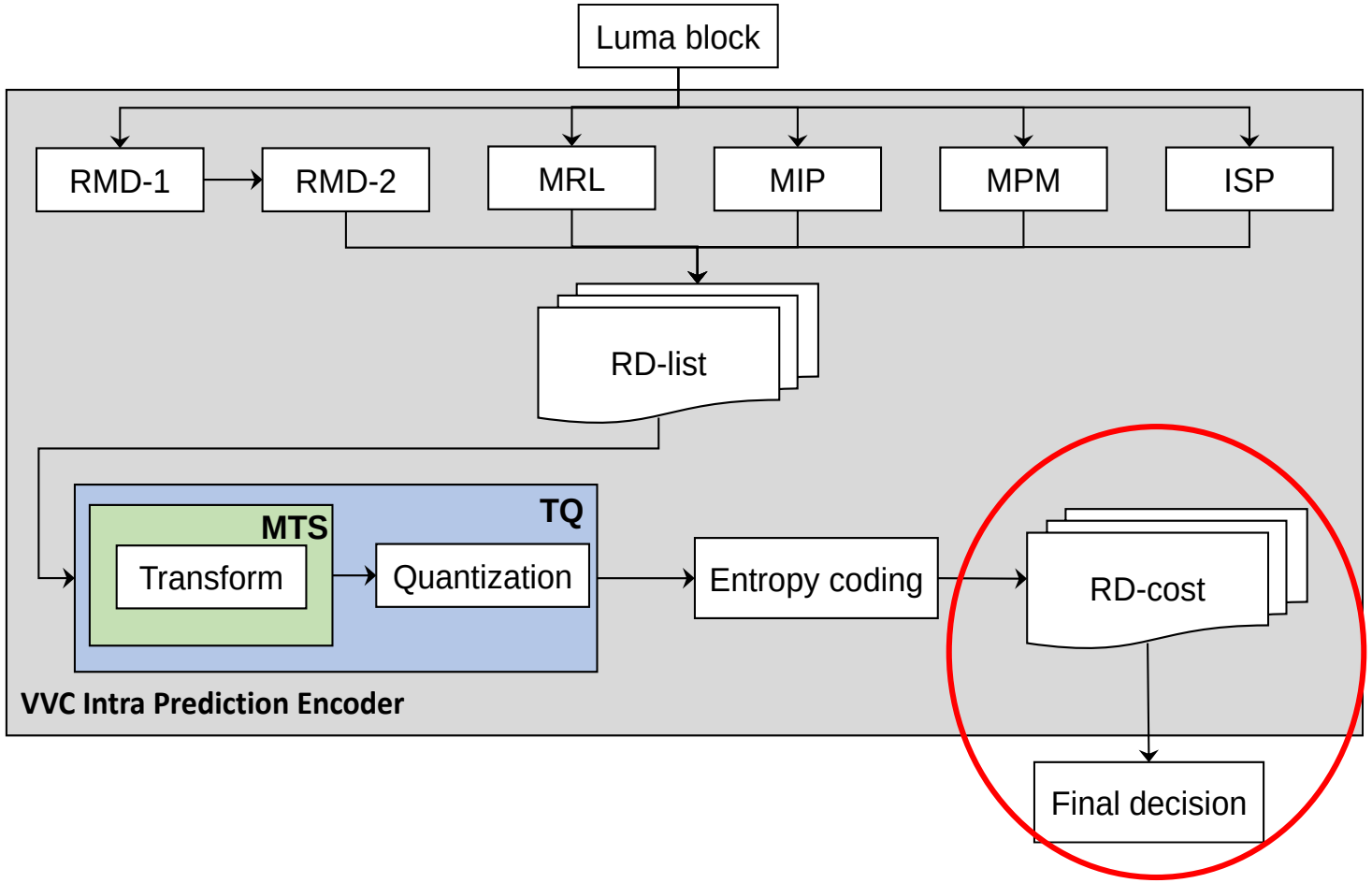
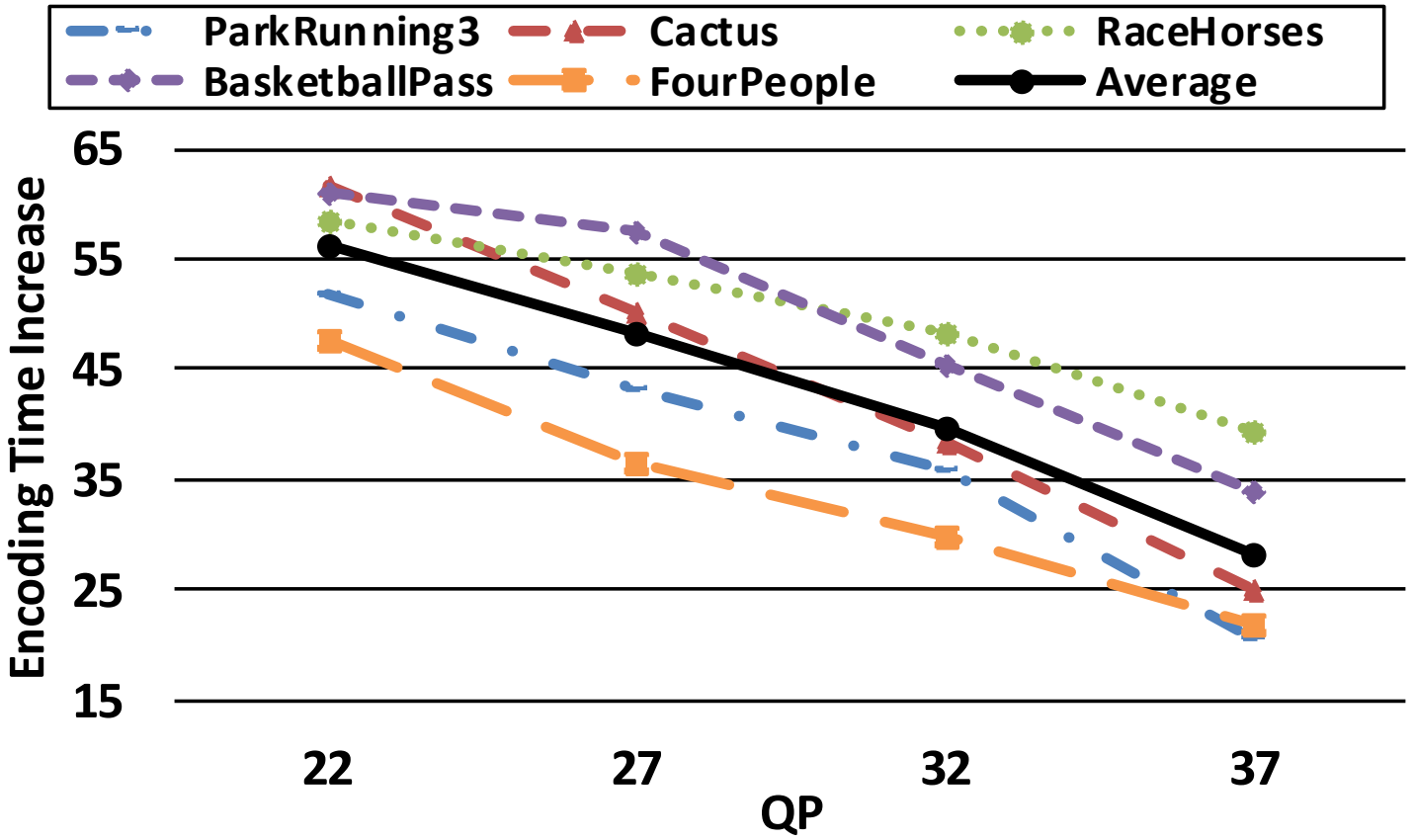


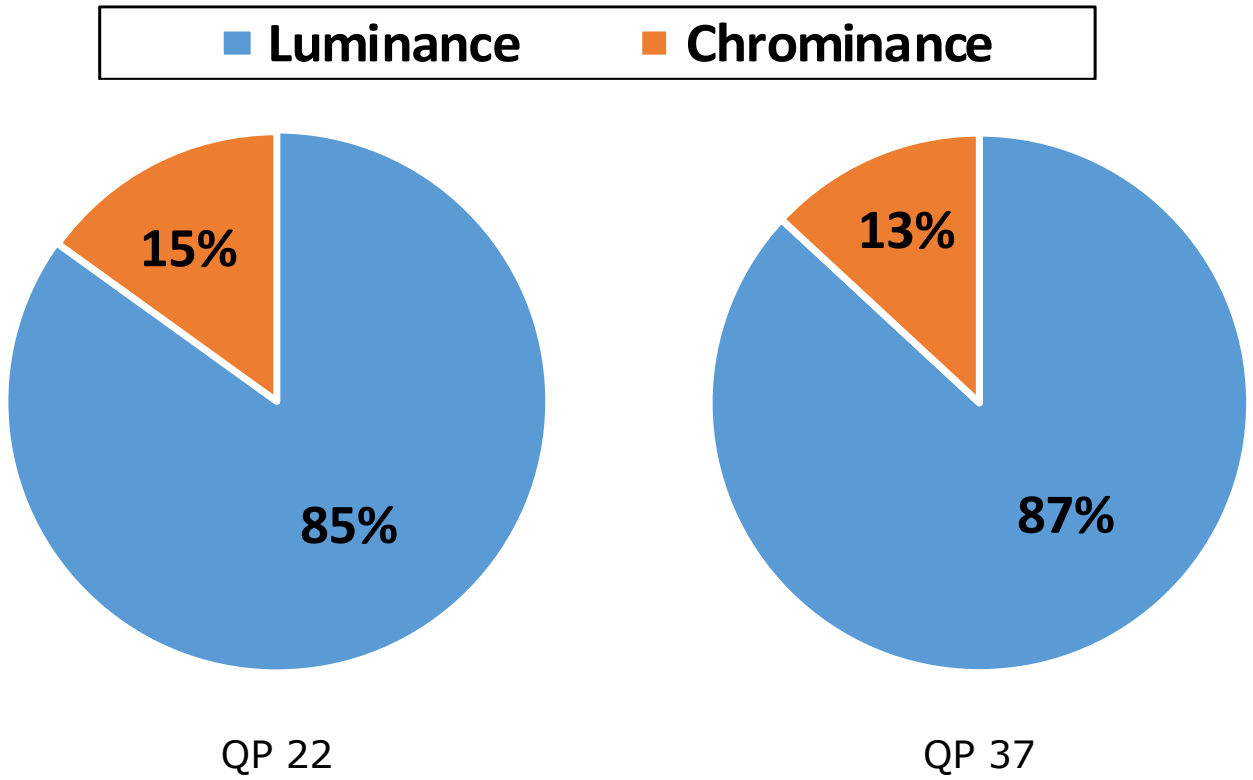
Experiments and Analysis

- Encoding time VTM 7.0 vs HM 16.20



Experiments and Analysis

- Encoding time distribution Luminance vs Chrominance



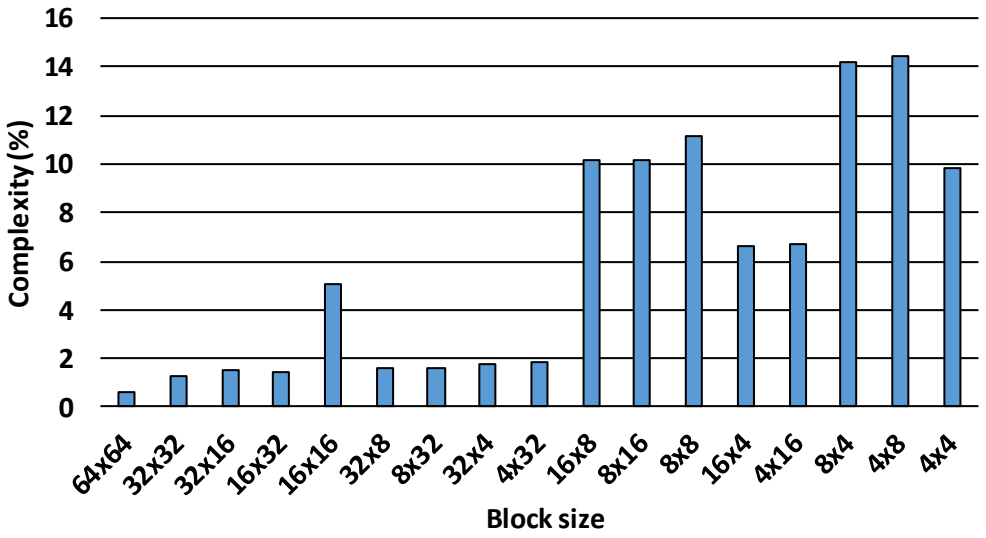
Experiments and Analysis

- Encoding time reduction when removing BT or TT

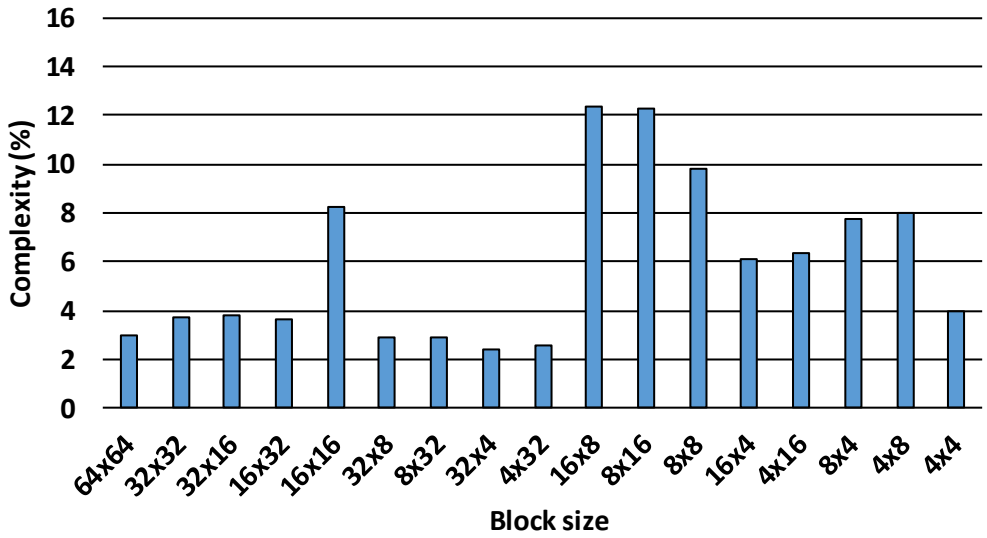
Class	Resolution	Encoding Time Reduction		
		No BT	No TT	No BT+TT
A1	3840×2160	67.9%	39.9%	85.5%
A2	3840×2160	77.1%	48.1%	92.7%
B	1920×1080	75.7%	47.5%	92.8%
C	832×480	79.3%	51.9%	95.1%
D	416×240	77.5%	51.2%	92.9%
E	1280×720	74.4%	47.2%	91.1%
Average		**75.3%**	**47.6%**	**91.7%**

Experiments and Analysis

- Block size complexity distribution



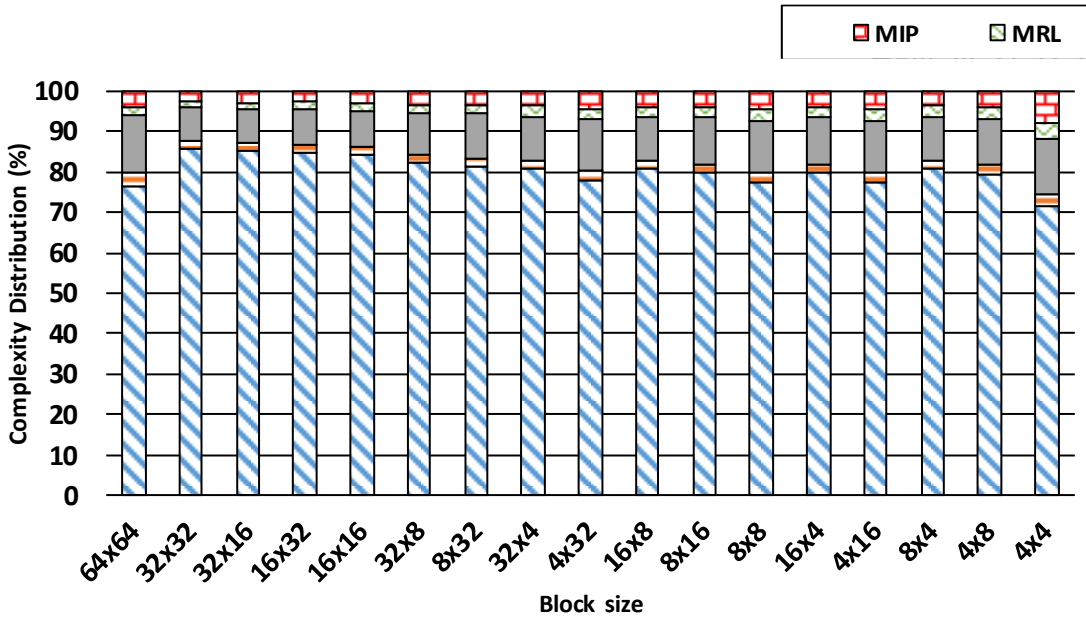
QP 22



QP 37

Experiments and Analysis

- Intra coding tools complexity distribution



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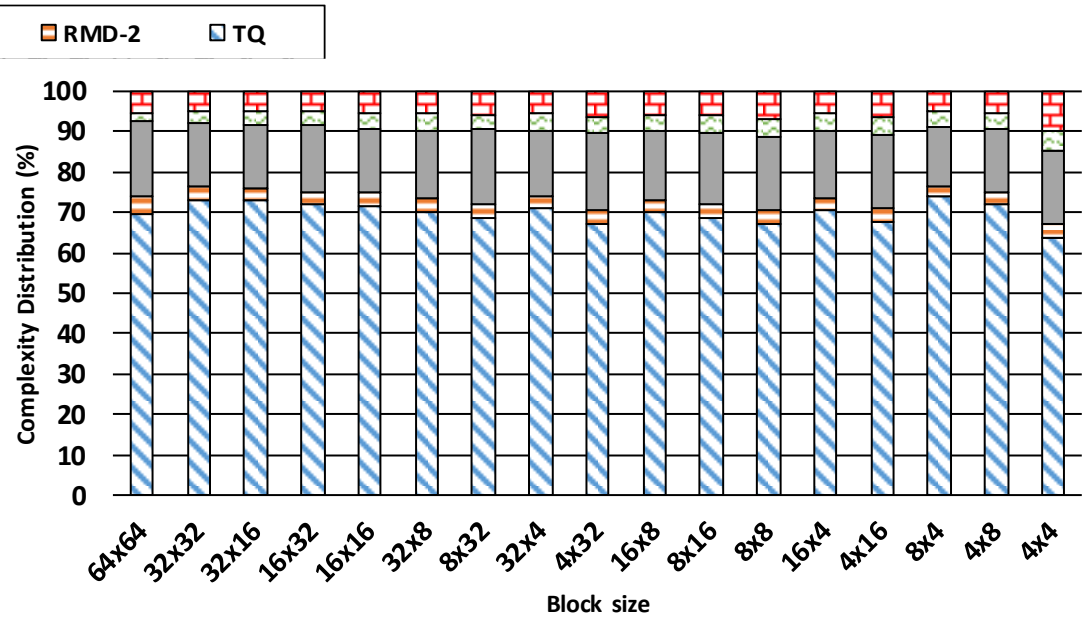

QP 37

Conclusions

- Several intra coding tools were introduced during the VVC standarization
  - Contribute to the complexity increase
- VTM execution time is much higher than HM
  - Complexity reduction solutions are required to enable real-time applications
- Based on the analyses, these solutions should be focused on
  - Luminance channel, MTT partitioning structure, residual coding, and RMD-1
- First analysis that provides a detailed complexity considering the steps of VVC intra coding

Thanks!

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