

# Quantization matrix for HEVC

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# Introduction

- Propose **quantization matrix for HEVC**
  - Similar proposal in Daegu (JCTVC-D024)
  - About 10 times more efficient than AVC method
  - Full implementation in HM 2.0
- Data size of quantization matrix, especially for large CU, is large and efficient encoding method to support quantization matrix is desired
  - See more detail requirements in **JCTVC-E056**.
- **The software is implemented in HM 2.0 and the source code is attached to this contribution**

# Quantization matrix

- In MPEG2 and AVC, quantization matrix is introduced to improve subjective quality
- Quantization matrix is widely used in consumer and professional video products, e.g. video camera, Blu-Ray disc, etc
- **Such well establish method in the existing standard should be supported by HEVC**
- In existing products, matrices are frequently changed and data size is large
  - See more detail in **JCTVC-E056**

# Problems

- In HM 2.0, transform and quantization **block sizes are up to 32x32**
- Large block transforms can provide improved coding efficiency, however **data size of quantization matrices becomes large**
- It is desirable to design **a compact representation format for the quantization matrices of large block sizes**

# Proposals

- **Support of quantization matrix in HEVC**
- **Efficient encoding method** of quantization matrix  
Support lossless and lossy coding of matrix
- **New NAL unit to transmit matrices**  
Parameters dynamically changes in bitstream should be moved, from PS to new NAL unit.
- **Create a common software branch at SVN**  
To accelerate the study of quantization  
**Attached software could be a good starting point**

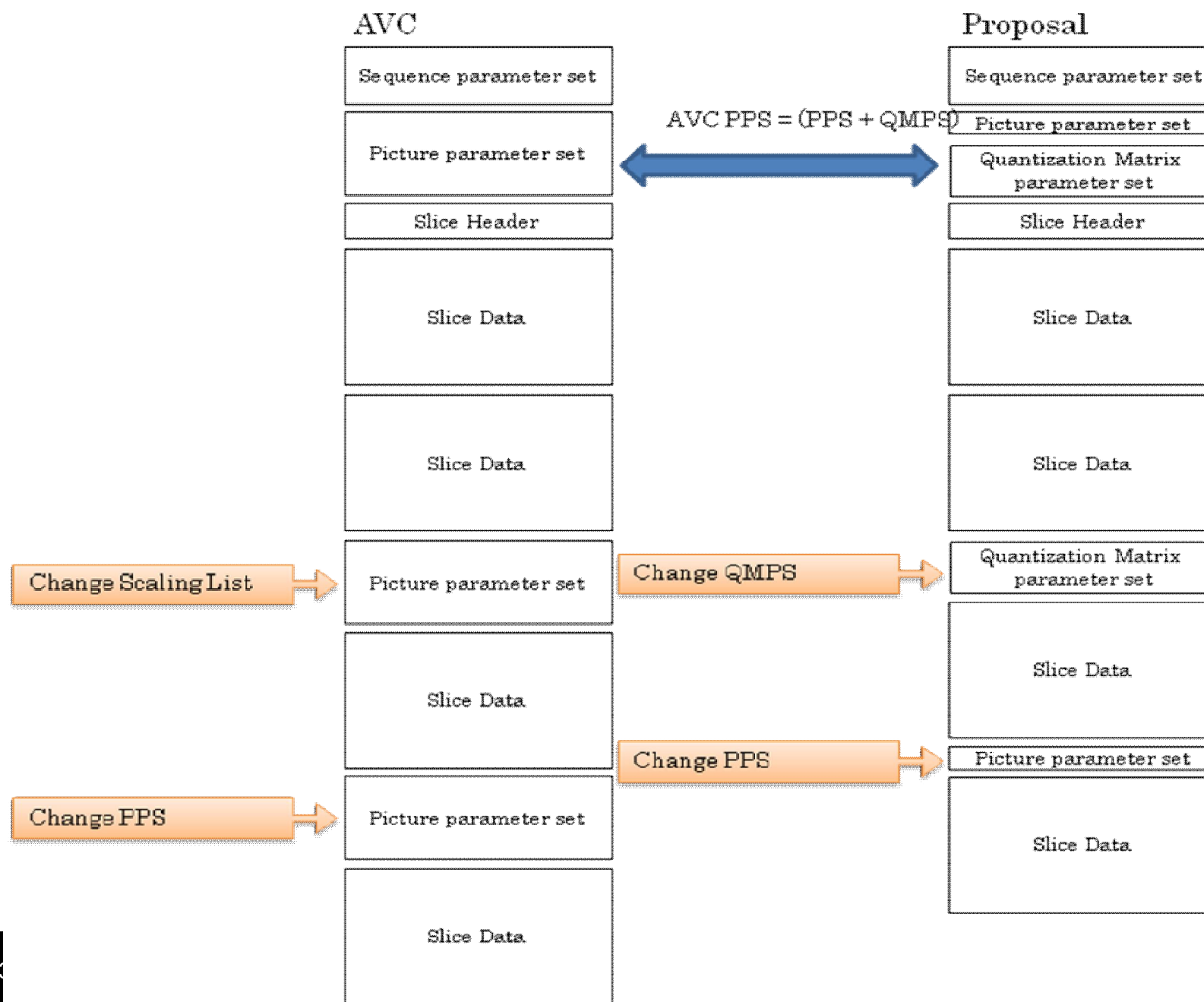
# Transmission of quantization matrix

- In AVC, **quantization matrix is encoded in SPS or PPS**
  - Necessary to encode quantization matrix in any time when PS changed
  - Necessary to encode PS in any time when quantization matrix is changed
  - Data size to transmit a combination of PS and quantization matrix is increased
- When the parameters in PS are **changed dynamically in a bitstream, the data size is significantly increased**
- It is possible to reduce data size by **moving such parameters from PPS to separate NAL unit**

## New NAL unit for quantization matrix

- Propose new NAL unit, **QMPS(Quantization Matrix Parameter Set)**
- It is possible to transmit **more than one QMPS NAL unit** in a bitstream
- Then **the value of quantization matrices** in QMPS NAL unit **can be updated at each slice**

# Example of NAL unit structure



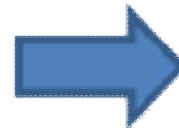


# Matrix representations

- Multiplication representation
  - Same as AVC
- Delta QP representation

$$QQP(i, j) = QP + W(i, j)$$

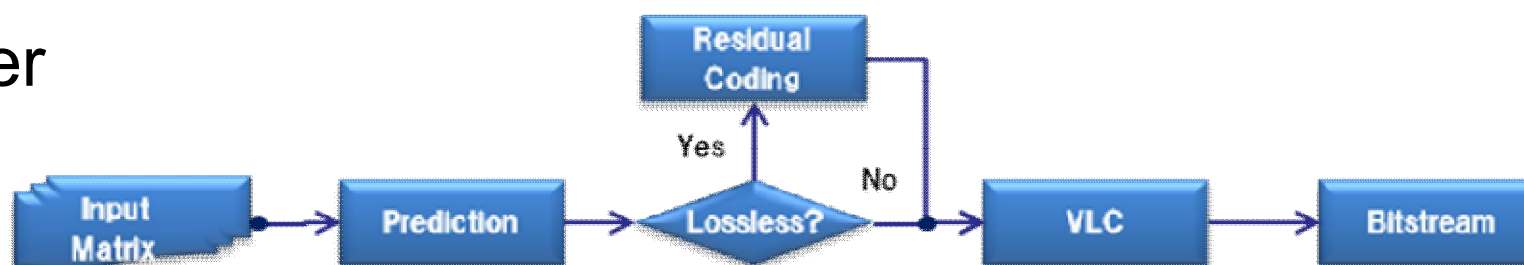
6	10	13	16	18	23	25	27
10	11	16	18	23	25	27	29
13	16	18	23	25	27	29	31
16	18	23	25	27	29	31	33
18	23	25	27	29	31	33	36
23	25	27	29	31	33	36	38
25	27	29	31	33	36	38	40
27	29	31	33	36	38	40	42



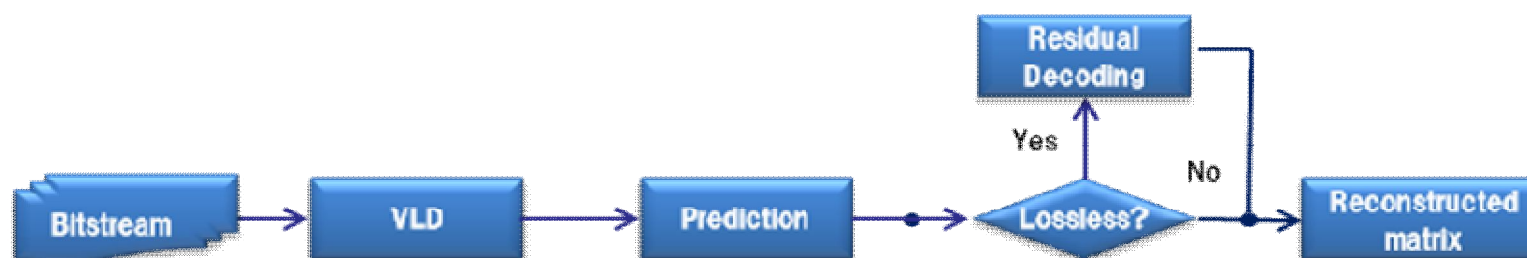
-9	-5	-2	0	1	3	3	4
-5	-4	0	1	3	3	4	5
-2	0	1	3	3	4	5	5
0	1	3	3	4	5	5	6
1	3	3	4	5	5	6	7
3	3	4	5	5	6	7	7
3	4	5	5	6	7	7	7
4	5	5	6	7	7	7	8

# Coding block diagram

## Encoder



## Decoder

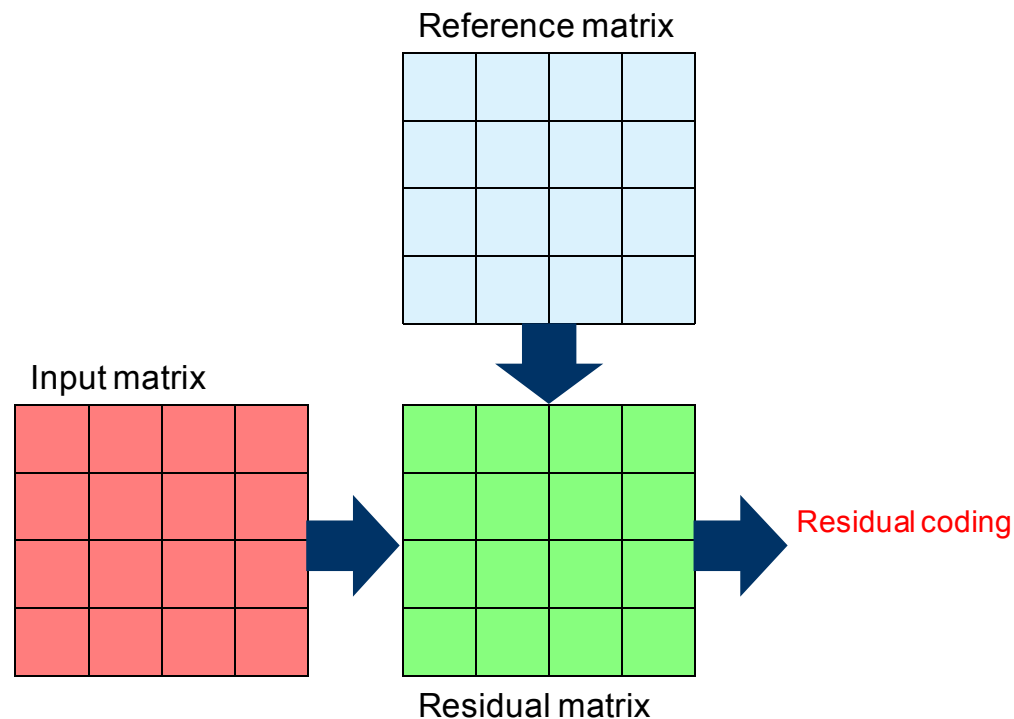


# Prediction

- 3 prediction modes
  - Copy mode
  - Axis mode
  - DPCM mode

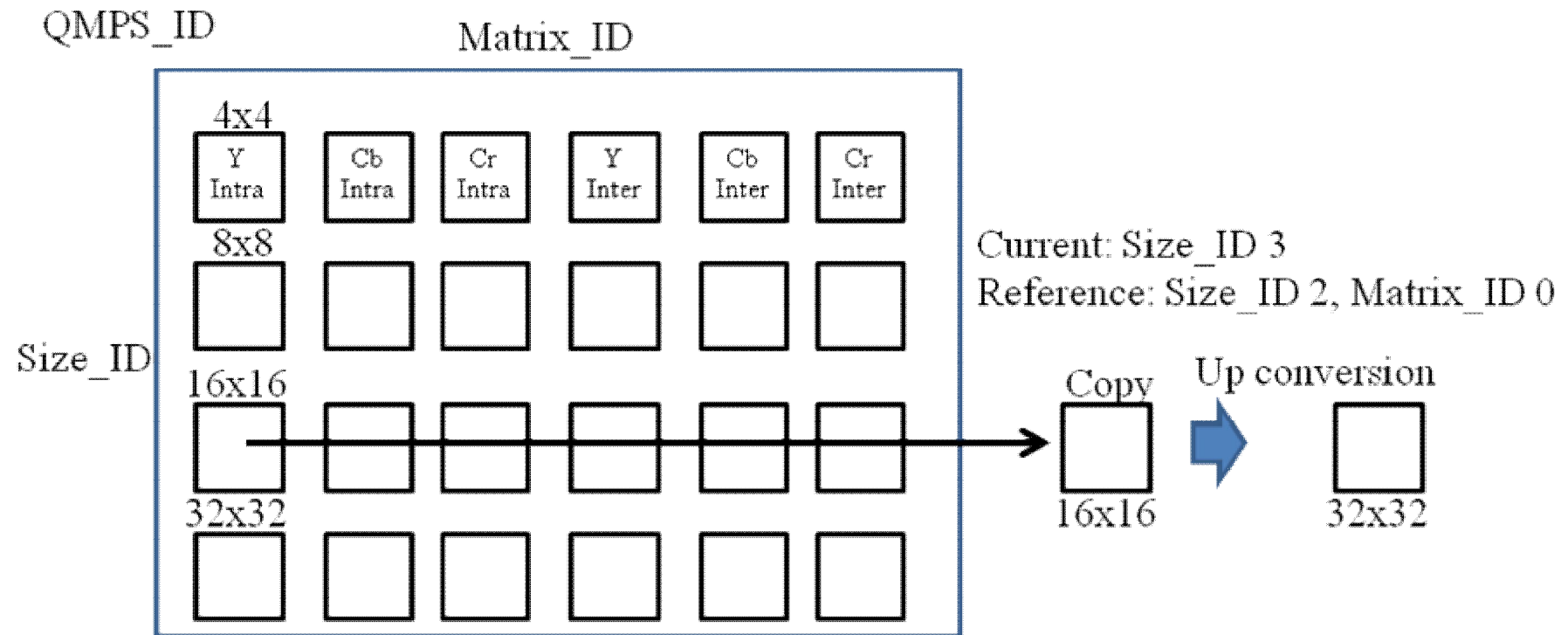
# Copy mode

- Use previously transmitted matrix as a predictor
  - Up sample if reference matrix is smaller
  - Down sample if reference matrix is larger
  - Use default matrix if refer to current



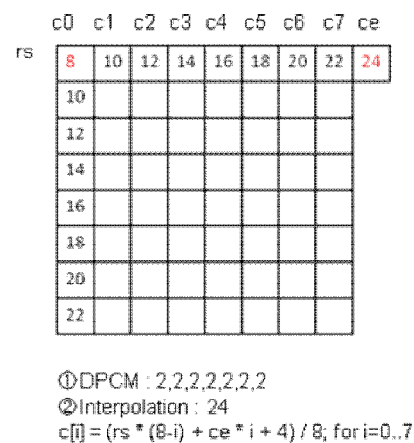
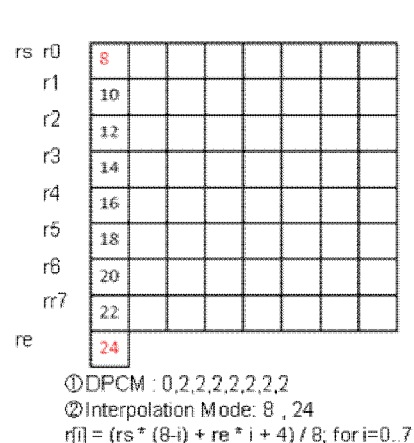
# Maintenance of matrix

- Matrices are stored in PS
- This matrix is used as predictor in copy mode

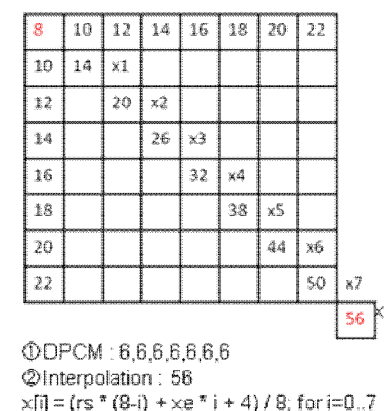


# Axis mode

- Parametric interpolation using V / H / D axis
- Reconstruct predictor as follows
  - Reconstruct V / H / D axis
  - Reconstruct other coeff by bi-linear interpolation

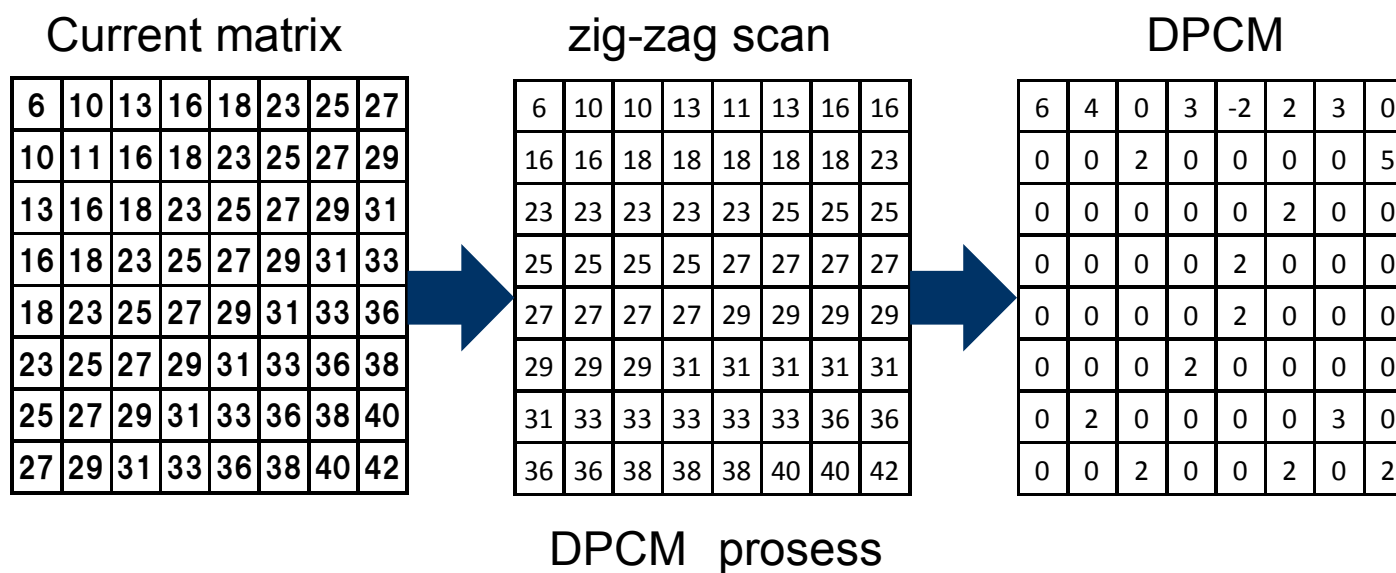


If copy\_from\_vertical\_flag==true,  
copy from vertical pixel values.



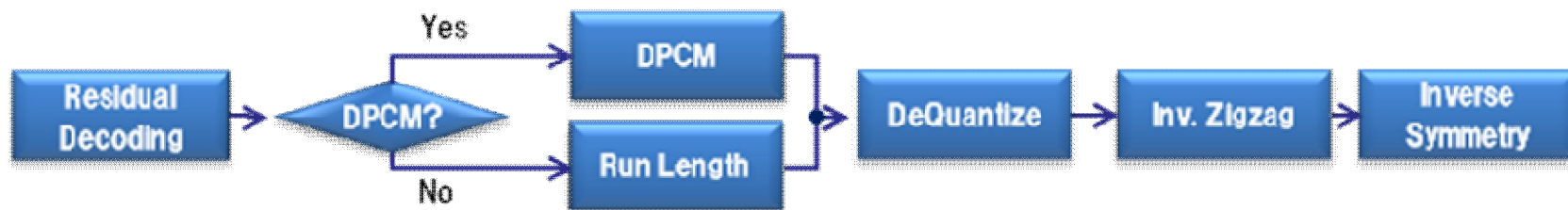
# DPCM mode

- DPCM like AVC



# Residual coding

- Residual from predictor is encoded by
  - DPCM or Run length coding
  - Quantization is applied for lossy coding
  - Can use symmetry coding
    - Similar to the TI's "135 degree symmetry" proposal (JCTVC-D024)
- Use LCEC VLC tables





# Simulation results

- Software: HM2.0
- Anchor: AVC like DPCM
- Compare generated bits for quantization matrix
- 4 Conditions (lossless/lossy/ matrix representation)
- Tested matrices: Annex B

	Quantization	DeltaQP representation
Cond1	Lossless	off
Cond2	2	off
Cond3	Lossless	on
Cond4	2	on

# Results

Lossless  
Multiplication

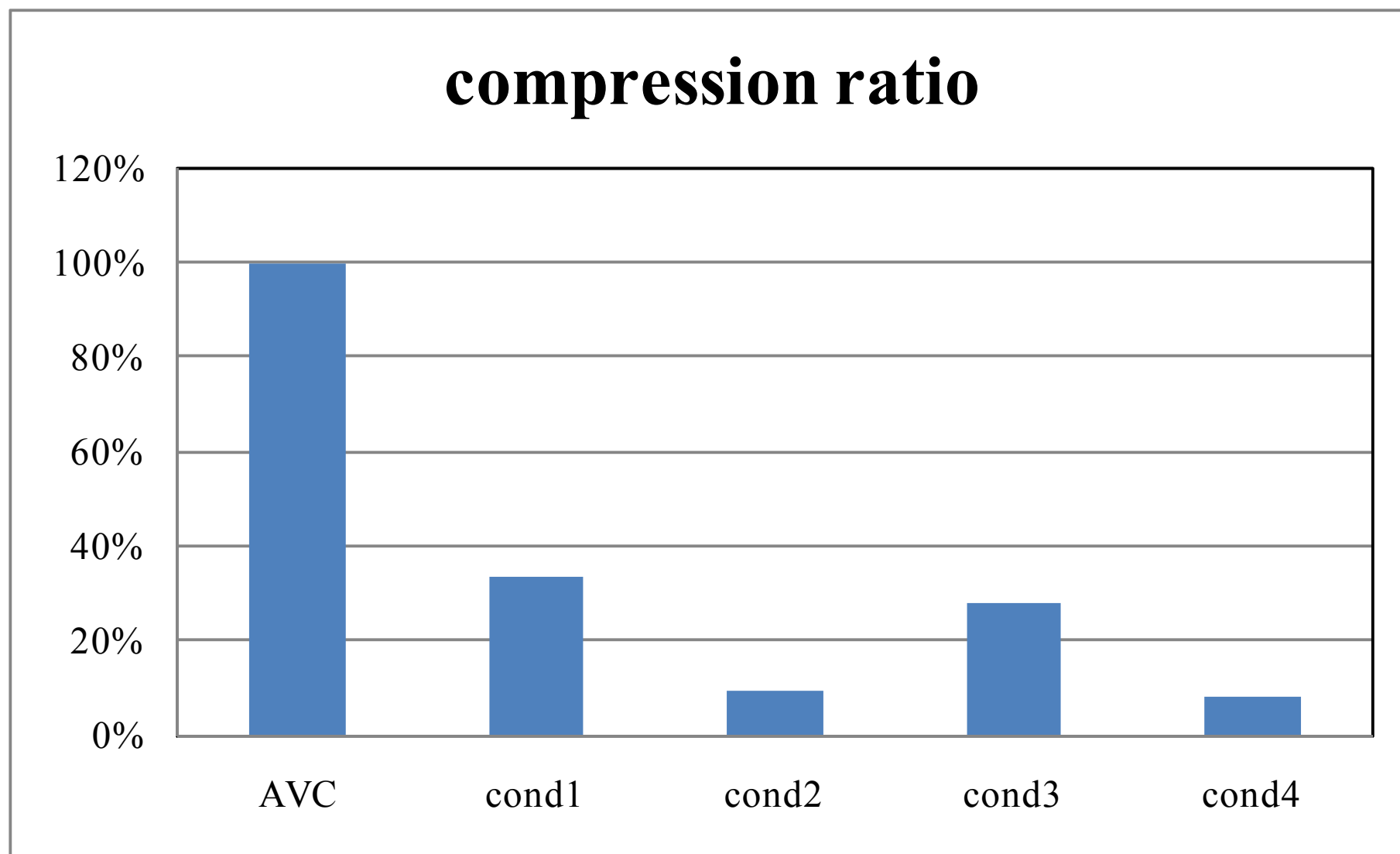
Lossy  
Multiplication

Lossless  
Delta QP

Lossy  
Delta QP

	AVC		Cond1				Cond2				Cond3				Cond4			
size	intra	inter	intra		inter		intra		inter		intra		inter		intra		inter	
	GenBits	GenBits	GenBits	Compression ratio[%]	GenBits	Compression ratio[%]	GenBits	Compression ratio[%]	GenBits	Compression ratio[%]	GenBits	Compression ratio[%]	GenBits	Compression ratio[%]	GenBits	Compression ratio[%]	GenBits	Compression ratio[%]
4x4	88	66	51	58.0%	44	66.7%	41	46.6%	34	51.5%	46	52.3%	37	56.1%	34	51.5%	30	45.5%
8x8	310	202	98	31.6%	78	38.6%	76	24.5%	70	34.7%	86	27.7%	78	38.6%	62	30.7%	58	28.7%
16x16	996	586	296	29.7%	256	43.7%	102	10.2%	70	11.9%	238	23.9%	192	32.8%	65	11.1%	82	14.0%
32x32	2876	1800	571	19.9%	904	50.2%	116	4.0%	155	8.6%	606	21.1%	652	36.2%	53	2.9%	182	10.1%
Total	4270	2654	1016	23.8%	1282	48.3%	335	7.8%	329	12.4%	976	22.9%	959	36.1%	214	5.0%	352	13.3%
	Total Bits		Total Bits		Compression ratio[%]		Total Bits		Compression ratio[%]		Total Bits		Compression ratio[%]		Total Bits		Compression ratio[%]	
	6924		2298		(33.2%)		664		(9.6%)		1935		(27.9%)		566		(8.2%)	

# Compression ratio



# Complexity

- Measured encoding/decoding time using HM2
- Simulation time is compared ON/OFF
  - Low complexity intra coding, 1 frame
  - > This is the most critical case: send matrix at all frame

	Encoding time	Decoding time
Quantization matrix Off	0.55	0.01
Quantization matrix ON	0.56	0.01
Increased time	1.8 %	0 %

# Subjective quality improvement (QP37)



QM Off



QM On

# Subjective quality improvement (QP37)



QM Off



QM On

# Subjective quality improvement (QP37)



QM Off



QM On

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