# F495 -- Higher granularity of quantization parameter scaling and adaptive delta QP signaling

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# Introduction

- The basic quantiser process
  - Forward $Z_{ij} = \mathrm{round}(Y_{ij}/Qstep)$
  - Inverse $Y_{ij} = Z_{ij} * Qstep$
- HEVC/AVC quantiser process
  - Forward $Z_{ij} = (Y_{ij} * Qscale_{ij} \quad (QP \% 6) >> (qbits + \quad (QP/6))$
  - Inverse $Y_{ij} = (Z_{ij} * DeqScale_{ij}(QP \% 6) << (QP/6)) >> dqbits$
- The quantization step size (Qstep) of HEVC Test Model
  - Qstep increases by approximately 12.25% with each increment of QP
  - Qstep doubles when QP is increased by 6

$$Qstep \approx 2^{\frac{QP-4}{6}} \quad , \text{with } QP = 0 \ldots 51$$

| QP | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | … |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qstep | 0.625 | 0.6875 | 0.8125 | 0.875 | 1 | 1.125 | 1.25 | 1.375 | 1.625 | 1.75 | 2 | 2.25 | … |

# Problem of current HM quantiser

- Experiments on HM3.0
  - Common test configuration (QP 22, 27, 32, 37)
  - Additional test with QP-1 (21, 26, 31, 36)
  - Bit rate increasing (QP-1) vs QP
    - Avg. 18.8% (non-intra configuration)
    - Max. 44.2%

| Test configuration | Bit rate increase (Qp-1 vs QP) | |
|---|---|---|
| | Average | Max |
| HE_AI | 12.9% | 29.0% |
| LC_AI | 12.8% | 26.1% |
| HE_RA | 18.3% | 36.5% |
| LC_RA | 18.2% | 38.5% |
| HE_LD | 19.5% | 44.2% |
| LC_LD | 19.2% | 44.2% |

- Problem statement
  - HM/AVC Qstep mapping is too coarse for fine and accurate rate/quality control
  - HM/AVC Qstep mapping is not flexible to fit different application scenario

# High granularity Qstep mapping (1)

- A straightforward extension of current Qstep mapping
  - Double QP scaling accuracy
  - Qstep increases by approximately 5.95% with each increment of QP
  - Qstep doubles when QP is increased by 12

$$Qstep \approx 2^{\frac{QP-8}{12}} \quad \text{, with QP = 0…103}$$

- Quantiser process
  - Inverse quantiser

$$Y_{ij} = (Z_{ij} * DeqScale_{ij}(QP \% 12) << (QP/12)) >> dqbits$$

DeqScale[12] = {40, 42, 45, 48, 51, 54, 57, 60, 64, 68, 72, 76}

# High granularity Qstep mapping (2)

- Experiments on HM3.0
  - Common test configuration QP 44 54 64 74, ( equivalent to 22, 27, 32, 37 in HM3.0)
  - Additional test with QP-1 43 53 63 73, ( equivalent to 21.5, 26.5, 31.5, 36.5 in HM3.0)
  - Bit rate increasing (QP-1) vs QP
    - Avg. 9.0% (non-intra configuration)
    - Max. 20.3%

| Test configuration | Bit rate increase (Qp-1 vs QP) | |
|---|---|---|
| | Average | Max |
| HE_AI | 6.4% | 14.0% |
| LC_AI | 6.4% | 12.6% |
| HE_RA | 8.8% | 17.3% |
| LC_RA | 8.7% | 18.0% |
| HE_LD | 9.2% | 20.3% |
| LC_LD | 9.1% | 20.1% |

- Advantage of straightforward extension
  - Easy adaptation of other modules that is related to QP
    - Deblocking filter
    - CABAC context model initialization
    - Lambda value (Encoder side)

# High granularity Qstep mapping (3)

- Delta QP value is doubled to achieve same level of Qstep change
  - {HM3.0, QP 26 -> 27} == {New mapping, QP 52 -> 54}
  - More bits overhead for coding CU level delta QP

| | | |
|---|---|---|
| 32 | 26 | 30 |
| 36 | 32 | 28 |
| 36 | 32 | 28 |

| | | |
|---|---|---|
| 64 | 52 | 60 |
| 72 | 64 | 56 |
| 72 | 64 | 56 |

| | | |
|---|---|---|
| 64 | 53 | 60 |
| 71 | 65 | 56 |
| 73 | 64 | 57 |

- Experiment on CE4 sub test 2 software
  - The software is used to evaluate bits overhead for coding dQP

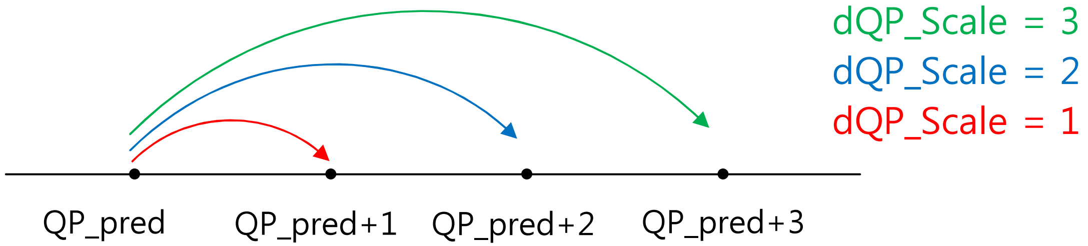
| Test configuration | Anchor CE4 sub test 2 software | | | |
|---|---|---|---|---|
| | Anchor dQP bits proportion | New dQP bits proportion | dQP Bits increase | BD-rate Loss |
| HE_AI | 3.6% | 4.9% | 38.3% | 1.2% |
| LC_AI | 3.5% | 4.7% | 37.9% | 1.2% |
| HE_RA | 3.5% | 4.7% | 36.5% | 1.2% |
| LC_RA | 3.6% | 4.9% | 38.3% | 1.3% |
| HE_LD | 4.3% | 5.8% | 35.9% | 1.5% |
| LC_LD | 4.7% | 6.4% | 38.5% | 1.8% |

# Adaptive delta QP signaling (1)

- QP of current CU calculated as

$$QP\_curr = QP\_pred + dQP * dQP\_Scale$$

- dQP=1 with different dQP_Scale
  - dQP_Scale = 1 -> Qstep increase 5.95%
  - dQP_Scale = 2 -> Qstep increase 12.25%
  - dQP_Scale = 3 -> Qstep increase 18.92%
  - Support the flexibility of tradeoff between better rate/quality control and dQP bits overhead.

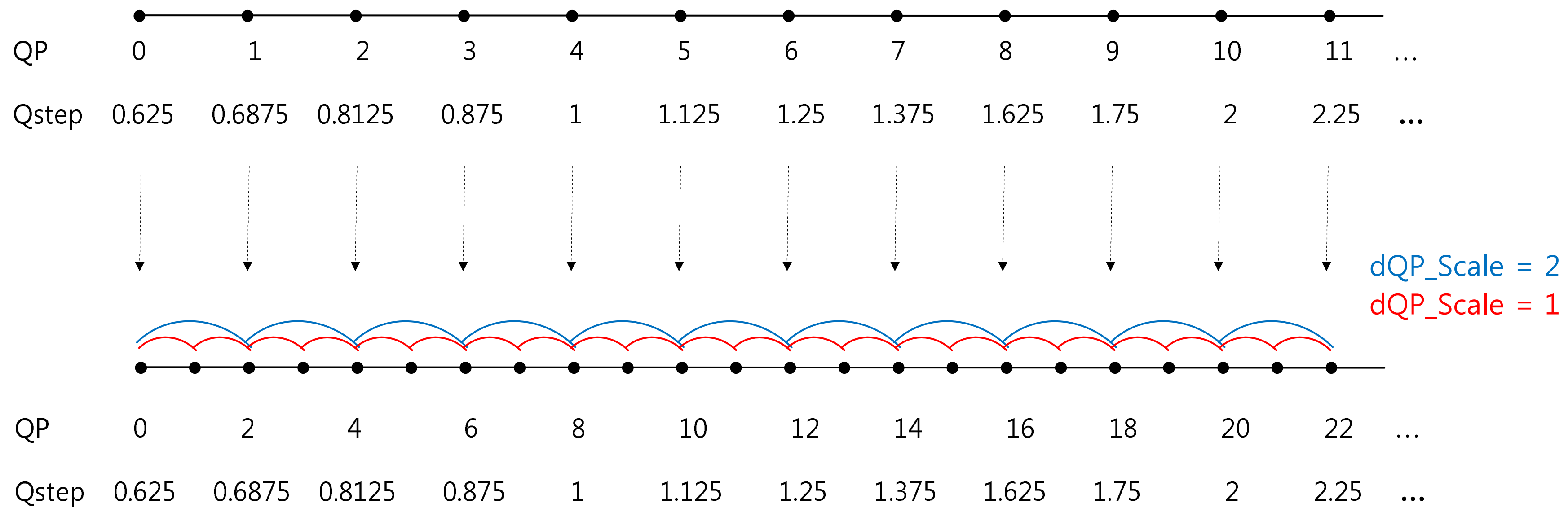



dQP=1 with different dQP_Scale

# Adaptive delta QP signaling (2)

- Slice level QP can be kept as highest level always
- dQP_Scale -> control CU-level QP update speed

- Set Slice QP = odd value and dQP_scale = 2,
  - Emulate current HEVC QP mapping solution



# High granularity Qstep mapping (3)

- Same level of Qstep change with variant dQP_Scale
  - With slice_QP = 64 (HM QP = 32)

**QP map**

dQP_Scale == 1:

| | | |
|---|---|---|
| 64 | 53 | 60 |
| 71 | 65 | 56 |
| 73 | 57 | 58 |

dQP_Scale ==2:

| | | |
|---|---|---|
| 64 | 52 | 60 |
| 72 | 64 | 56 |
| 72 | 56 | 58 |

dQP_Scale ==3:

| | | |
|---|---|---|
| 64 | 52 | 61 |
| 70 | 64 | 55 |
| 73 | 58 | 58 |

**dQP map**

dQP_Scale == 1:

| | | |
|---|---|---|
| 0 | -11 | 7 |
| 7 | -6 | -9 |
| 2 | 16 | 1 |

dQP_Scale ==2:

| | | |
|---|---|---|
| 0 | -6 | 4 |
| 4 | -4 | -4 |
| 0 | 8 | 1 |

dQP_Scale ==3:

| | | |
|---|---|---|
| 0 | -4 | 3 |
| 3 | -3 | -3 |
| 1 | 5 | 0 |

HM3.1:

| | | |
|---|---|---|
| 32 | 26 | 30 |
| 36 | 32 | 28 |
| 36 | 28 | 29 |

| | | |
|---|---|---|
| 0 | -6 | 4 |
| 4 | -4 | -4 |
| 0 | 8 | 1 |

# High granularity Qstep mapping (4)

- Experiment on CE4 sub test 2 software
  - The software is used to evaluate bits overhead for coding dQP

| Test configuration | Anchor CE4 Sub_test 2 | dQP_Scale == 1 | | dQP_Scale == 3 | |
|---|---|---|---|---|---|
| | dQP bits proportion | dQP bits proportion | dQP Bits increase | dQP bits proportion | dQP Bits increase |
| HE_AI | 3.6% | 4.9% | 38.3% | 2.9% | -20.2% |
| LC_AI | 3.5% | 4.7% | 37.9% | 2.9% | -17.3% |
| HE_RA | 3.5% | 4.7% | 36.5% | 2.8% | -19.8% |
| LC_RA | 3.6% | 4.9% | 38.3% | 3.0% | -18.2% |
| HE_LD | 4.3% | 5.8% | 35.9% | 3.5% | -19.6% |
| LC_LD | 4.7% | 6.4% | 38.5% | 3.9% | -18.5% |

# Summary

- Double the Qstep granularity of HEVC
  - 12.25% -> 5.95% Qstep increase with each QP increment
  - Avg. 18.2% ->9.0% bit increase with each QP increment

- Adaptive delta QP signalling with dQP_Scale in slice head
  - Control CU level Qstep/QP update speed
    - Trade-off of better rate/qualilty control and dQP bits over head
  - Slice level high QP mapping granularity
  - Constant forward/backward quantiser process

- Propose consideration adoption of
  - Fine granularity Qstep mapping
  - Adaptive dQP signalling

Thank you !