APPS001-Codensity^{TM} T408 Encoder Quality Application Note

V2.0

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1 Table of Abbreviations

Abbreviation:	Full Form:
AI	Artificial Intelligence
API	Application Programming Interface
AUD	Access Unit Delimiters
AV	Audio Video
AV1	Alliance Open Media Video 1 Codec
CABAC	Context Adaptive Binary Arithmetic Coding
CBR	Constant Bit Rate
CPU	Central Processing Unit
CRF	Constant Rate Factor
DSP	Digital Signal Processing
EOF	End Of File
FIXQB	Fixed Quantization Parameter
FF	Form Factor
FPS	Frames Per Second
GOP	Group of pictures
HDR	High Dynamic Range
HHHL	Half Height, Half Length
HHFL	Half Height, Full Length
HLG	Hybrid Log Gamma
HRD	Hypothetical Reference Decoder
IE	Inference Engine
Mbps	Mega Bit per second
MBps	Mega Byte per second
NLP	Natural Language Processing
NPU	Neural Processing Unit
NVMe	Non-Volatile Memory express
PCIe	Peripheral Component Interconnect express
PPS	Picture Parameter Set
QP	Quoted Printable
RGB	Red Green Blue
RGBA	Red Green Blue Alpha
RDO	Optimization
ROI	Region of interest
SDK	Software Development Kit
SEI	Supplemental Enhancement Information
SRIOV	Single Root I/O Virtualization
SPS	Sequence Parameter Set
VBR	Variable Bit Rat
VCL	Video Coding Layer
VPS	Video Parameter Set
VUI	Video Usability Information

2 References

Technical Notes:

Specifications:

3 Background

This document describes the settings that affect the H264 and H265 encoder quality on a Codensity T408 and T432 Video Transcoder device.

3.1 Intended Audience

This document is intended for to help engineers/technicians/developers operating NETINT transcoders better understand the configuration of video encoder quality parameters.

3.2 Compatibility

Software Compatibility

-

Hardware Compatibility

-

Operation system

-

4 Encoding mode

There are many definitions of encoding mode. For example, VBR (variable bitrate mode) or ABR (average bitrate mode), CQP (constant QP mode) or CQ (Constant Quality mode). Unfortunately, the real model behind some of these modes are not very clear. We can generally classify them into three categories:

- Constant QP mode: Use a fixed QP (quantization parameter) to encode each frame. The QP is from 0 to 51. With this mode, the output bitrate is not predictable. This mode is only used for evaluation in lab.
- CQ mode (or CRF constant rate factor mode): this mode tries to maintain a constant quality for each frame based on motion. It is an improvement from CQP and gives lower QP (that means better quality) to frames important or sensitive to viewer (for example, with low motion) and gives higher QP (that means lower quality) to frames not important. This mode doesn't control bitrate but gives the best result for static encoding (for example, a file). Currently, we don't support this mode in T408.
- Bitrate control mode. This method gives a target bitrate and the bitrate control algorithm will try to match this bitrate on average over a period. We usually call it VBR mode or ABR mode. Since the control of the average bitrate is over a buffer (VBV buffer), we also call it VBV mode.

  Once the average time (or the VBV buffer) is small, the output bitrate will fluctuate little around the average bitrate (we sometime call it CBR mode, constant bitrate). Once the average time (or the VBV buffer) is large, the output bitrate will fluctuate large around the average bitrate.

  This mode is the most popular mode used in network transportation where the bitrate should be well controlled. We will only talk about this mode in the remaining of this document.

  In T408, VBV buffer is controlled by parameter RcInitDelay. The unit for this parameter is millisecond. Normally we set it to 3000. But for a CBR mode, you may reduce it to 300.

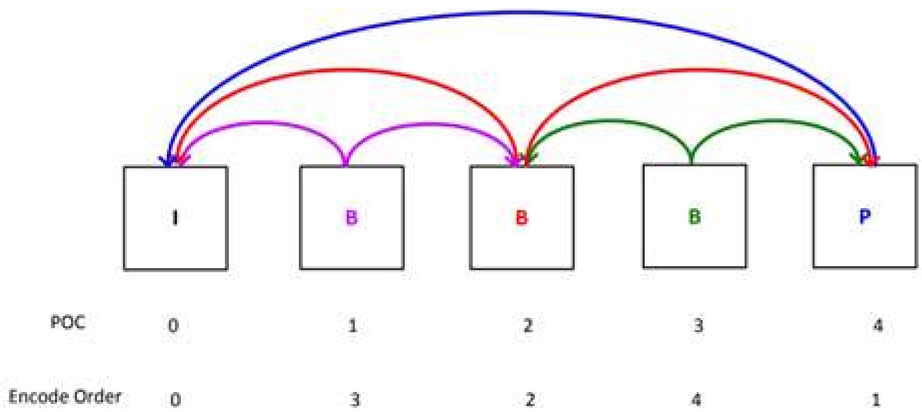
5 Parameters affect encoding efficiency

5.1 GOP preset

In T408, a small group of pictures that can be used as reference for each other is defined as a GOP. This definition is different from the GOP definition in H264 or H265 spec.
The maximum GOP size is only 8 in T408.
There are 8 predefined GOP structures which are usually enough for normal applications.

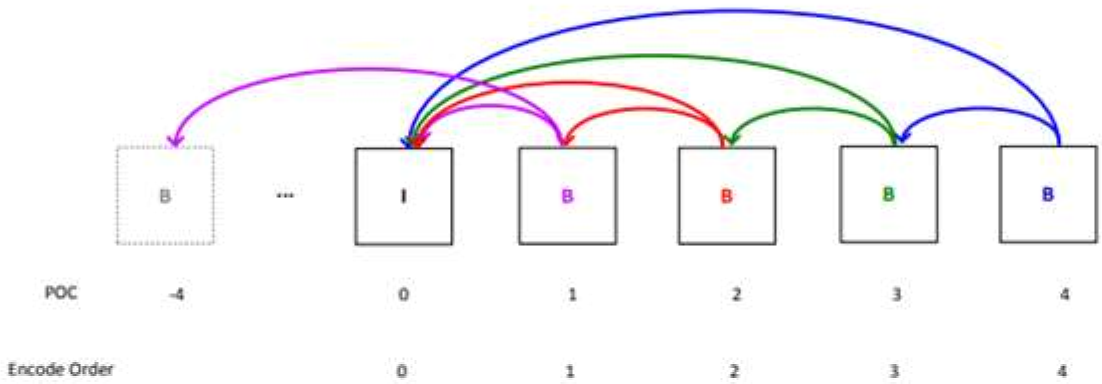
gopPresetIdx

```
Defines the group of picture pattern. For custom GOP,
please see the Custom Gop Parameters Section.
Supported values are as follows:
0 : Custom Gop
1 : I-I-I-I,..I (all intra, gop_size=1)
2 : I-P-P-P,… P (consecutive P, gop_size=1)
3 : I-B-B-B,…B (consecutive B, gop_size=1)
4 : I-B-P-B-P,… (gop_size=2)
5 : I-B-B-B-P,… (gop_size=4)
6 : I-P-P-P-P,… (consecutive P, gop_size=4)
7 : I-B-B-B-B,… (consecutive B, gop_size=4)
8 : I-B-B-B-B-B-B-B-B,… (random access, gop_size=8)<<<
default 5
```



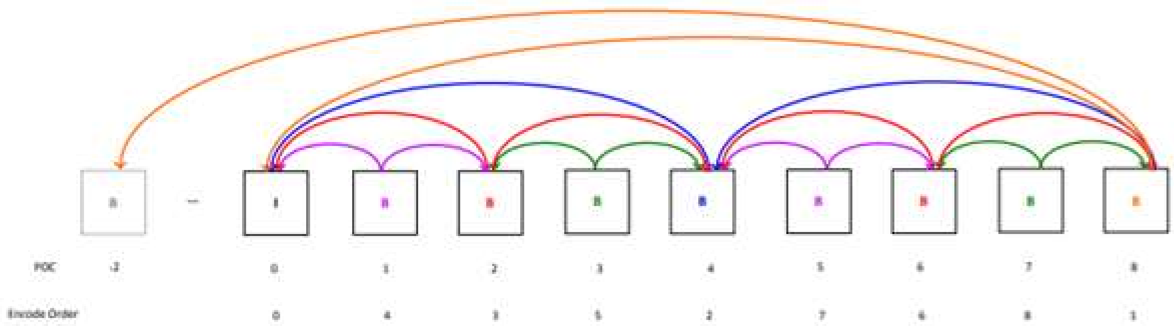
Frame#	Type	POC	QPoffset	temporal_id	1st_ref POC	2nd_ref_POC
Frame1	P	4	1	0	0	-4
Frame2	B	2	3	0	0	4
Frame3	B	1	5	0	0	2
Frame4	B	3	5	0	2	4

Figure 1 Definition of GOP preset 5



Frame#	Type	POC	QPoffset	temporal_id	1st_ref POC	2nd_ref_POC
Frame1	B	1	5	0	0	-4
Frame2	B	2	3	0	1	0
Frame3	B	3	5	0	2	0
Frame4	B	4	1	0	3	0

Figure 2 Definition of GOP preset 7



Frame#	Type	POC	QPoffset	temporal_id	1st_ref POC	2nd_ref_POC
Frame1	B	8	1	0	0	-8
Frame2	B	4	3	0	0	8
Frame3	B	2	5	0	0	4
Frame4	B	1	8	0	0	2
Frame5	B	3	8	0	2	4
Frame6	B	6	5	0	4	8
Frame7	B	5	8	0	4	6
Frame8	B	7	8	0	6	8

Figure 3 Definition of GOP preset 8

To achieve good compression efficiency, a frame must refer to more adjacent frames. GOP preset 5, 7 or 8 are the most popular presets we can use to achieve good compression results. Usually GOP preset 8 is recommended.
If user want to define their own GOP structure, or change the QP offset defined in these predefined GOP preset, they can refer to IntegrationProgrammingGuideT408.

5.2 I period

`intraPeriod`

`Key frame interval. Must be multiple of GOP size as defined by the gopPresetIdx. The range is 0 to 1024. A value of 0 implies an infinite period.`
`default` `92`

Usually a large intraPeriod will give encoder more flexibility on frames between two I frames and get better encoding efficiency.

5.3 HVS control

`hvsQPEnable`

```
Enable or disable CU QP adjustment for subjective
quality enhancement. Supported values are as follows:
0: disable
1: enable
default 1
```

Usually we find enabling this hvs (human visual system) control can give better video quality results. To enable hvs feature the following parameters need to be set: hvsQPEnable=1, hvsQpScale=2, maxDeltaQp=10. Here is an example command:

```
$ sudo ffmpeg -i test.yuv -c:v h264_ni_enc -xcoder-params '
hvsQPEnable=1:hvsQpScale=2:maxDeltaQp=10:gopPresetIdx=5:intraPeri
od=128:RcEnable=1:RcInitDelay=3000:bitrate=2500000' output.265
```

6 Examples

6.1 Recommended H265 encoding

```
$ sudo ./ffmpeg -c:v h264_ni_dec -i test.264 -vsync 0 -c:v
h265_ni_enc -xcoder-params
"gopPresetIdx=8:intraPeriod=256:RcEnable=1:RcInitDelay=3000:
hvsQPEnable=0:bitrate=5000000" output.265
```

This is the recommended encoding command for H265. The bitrate here is 5Mbps but user can change according their requirement.

6.2 Recommended H264 encoding

```
$ sudo ./ffmpeg -c:v h264_ni_dec -i test.264 -vsync 0 -c:v
h264_ni_enc -xcoder-params
"gopPresetIdx=8:intraPeriod=256:RcEnable=1:RcInitDelay=3000:
hvsQPEnable=0:bitrate=5000000" output.264
```

This is the recommended encoding command for H264. The bitrate here is 5Mbps but user can change according to their requirement.

6.3 Recommended encoding with less bitrate variation

```
$ sudo ./ffmpeg -c:v h264_ni_dec -i test.264 -vsync 0 -c:v
h265_ni_enc -xcoder-params
"gopPresetIdx=8:intraPeriod=256:RcEnable=1:RcInitDelay=300:
hvsQPEnable=0:bitrate=5000000" output.265
```

7 Customized GOP (only for advanced users)

Use customized GOP can improve the BD-rate between 1% to 5%. Please refer to IntegrationProgrammingGuideT408 for details.

For example, this is a H264->H264 transcoding example based on GOP 8. The QP for frames referred more are improved (smaller).

```
ffmpeg -c:v h264_ni_dec -i input.264 -vsync 0 -c:v h264_ni_enc -
xcoder-params
"frameRate=24:gopPresetIdx=0:intraPeriod=128:RcEnable=1:RcInitDel
ay=3000:bitrate=2000000:hvsQPEnable=0" -xcoder-gop
"customGopSize=8:g0picType=2:g0pocOffset=8:g0picQp=1:g0numRefPicL
0=1:g0refPocL0=0:g0refPocL1=-
8:g0temporalId=0:g1picType=2:g1pocOffset=4:g1picQp=3:g1numRefPicL
0=1:g1refPocL0=0:g1refPocL1=8:g1temporalId=0:g2picType=2:g2pocOff
set=2:g2picQp=5:g2numRefPicL0=1:g2refPocL0=0:g2refPocL1=4:g2tempo
ralId=0:g3picType=2:g3pocOffset=1:g3picQp=7:g3numRefPicL0=1:g3ref
PocL0=0:g3refPocL1=2:g3temporalId=0:g4picType=2:g4pocOffset=3:g4p
icQp=7:g4numRefPicL0=1:g4refPocL0=2:g4refPocL1=4:g4temporalId=0:g
5picType=2:g5pocOffset=6:g5picQp=5:g5numRefPicL0=1:g5refPocL0=4:g
5refPocL1=8:g5temporalId=0:g6picType=2:g6pocOffset=5:g6picQp=7:g6
numRefPicL0=1:g6refPocL0=4:g6refPocL1=6:g6temporalId=0:g7picType=
2:g7pocOffset=7:g7picQp=7:g7numRefPicL0=1:g7refPocL0=6:g7refPocL1
=8:g7temporalId=0" -y output.264
```

8 Revision History

Version	Change	Create Date	Author
1.0	Document Created	Sept 10,2019	Tom Han
1.1	Fixed a few typo	Sept 24,2019	Tom Han
1.2	improve HVS control section	Nov 9, 2020	Achraf Jerbi
2.0	Update to new template	November 22, 2021	Balwinder Sidhu

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