|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  19th Meeting: Strasbourg, FR, 17–24 Oct. 2014 | Document: JCTVC-S0175 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **CE10: Test 7.1 Constrained run for Intra String Copy** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | Feng Zou Ying Chen Vadim Seregin  Marta Karczewicz  5775 Morehouse Drive San Diego, CA, 92122 | Tel: Email: | +1-858-845-1115 [fzou@qti.qualcomm.com](mailto:fzou@qti.qualcomm.com) [cheny@qti.qualcomm.com](mailto:cheny@qti.qualcomm.com) |
| *Source:* | Qualcomm Incorporated | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

This proposal presents results by constraining the current Intra String Copy method to reduce worst case memory bandwidth access. The implementation is based on the common CE software of the current CE10. It has been discussed that it would be necessary to reduce the memory bandwidth and one way is to access at lease *T* pixels during each String Copy. The simulation results show that such a constraint (with *T* equal to 4) as implemented based on CE10 common software leads to 0.4% and 0.2% bitrate increase for text & graphics with motion, 1080p RGB and YUV respectively under CTC. In that case, the coding efficiency benefit of the Intra String Copy method drops to 1.7% for text & graphics with motion, 1080p RGB under CTC and 1.1% when 4 CTUs are constrained for both Intra string copy and Intra Block Copy.

# Introduction

In the 18th JCT-VC meeting in Sapporo, CE10 [1] was established to study different Intra String Copy methods. In CE10, a common CE software is designed based on JCTVC-R0098 [2] and JCTVC-R0140 [3]. However, the matching string in the common software can be as short as 1 pixel, which requires much more memory access compared with Intra BC. JCTVC-R0225 [4] proposed the constrained run for Intra String Copy and is studied in CE10 Test 7.1 to reduce the memory access.

# Simulation results

The proposed scheme is implemented on CE10 common software and tested using the common test condition defined in [6]. Table 1 demonstrates the coding performance under full frame Intra BC test conditions when matching length constraint T=4 is applied.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | CE10 SW |  | Proposed CE10 Constrained Run | | |
|  | **All Intra** | | | **All Intra** | | |
|  | G/Y | B/U | R/V | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p | -2.1% | -2.3% | -2.4% | -1.7% | -2.0% | -1.9% |
| RGB, text & graphics with motion,720p | -0.6% | -0.8% | -0.6% | -0.5% | -0.6% | -0.5% |
| RGB, mixed content, 1440p | -0.2% | -0.1% | -0.2% | -0.1% | -0.1% | -0.1% |
| RGB, mixed content, 1080p | -0.5% | -0.6% | -0.5% | -0.4% | -0.4% | -0.3% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p | -1.7% | -1.9% | -1.8% | -1.5% | -1.6% | -1.5% |
| YUV, text & graphics with motion,720p | -0.4% | -0.5% | -0.5% | -0.3% | -0.3% | -0.5% |
| YUV, mixed content, 1440p | 0.0% | -0.2% | -0.2% | -0.1% | -0.2% | -0.2% |
| YUV, mixed content, 1080p | -0.3% | -0.4% | -0.3% | -0.2% | -0.3% | -0.3% |
| YUV, Animation, 720p | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.0% |
| YUV, camera captured, 1080p | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.1% |
| Enc Time[%] | 150% | | | 145% | | |
| Dec Time[%] | 100% | | | 99% | | |

## Worst case memory access for Intra string copy

In order to compare the Intra string copy methods with the current design, we make the following assumptions as discussed in BOG report [5].

Note that such a method is just a starting point, a more accurate method for calculating the worst case memory access may lead to relatively higher worst memory access numbers.

1. Each fetch of memory contains *S* pixel values in the reference memory and *S* is typically larger than 1.
2. Fetching of *S* pixel has the same price as fetching *mxn* pixels if *S* (e.g., 16) is equal to *mxn (e.g., 4x4).*
3. Even each fetch has a target of 1 pixel, the number of accessed pixels is equal to *S.*

AI case:

Typical values of *P* are shown as below for dictionary coding methods, assuming the minimal run length is equal to T. Here MxN equal to 8x8 represents the block size that hits the worst case. Each memory fetch is contains *S* samples (similar to the *mxn* memory access pattern in case of motion compensation).

Here *P* is the number of pixels that need to be accessed (in average) for each single pixel coded with Intra String Copy mode.



*Note that this means typically P is equal to S/T.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *S, T* | 4, 4 | **8**, 4 | 16, 4 | n/a | n/a |
| *P* | 1 | **2** | **4** | n/a | n/a |

Therefore, when the minimum run length *T* is equal to 4, and S is equal to 16, meaning each fetch pattern takes at least 16 pixels, the worst case memory access *P* is decreased from 16 to 4, as highlighted in red.

Note that although the worst case memory access can be decreased in the above case when S is equal to 16, accessing the 16 pixels may be more expensive than accessing e.g., an 4x4 block, so the reduced memory bandwidth number may be still larger than 4, when *S* is 16 and *T* is 4.

# Conclusion

Currently there is not a clear methodology to evaluate the worst case memory bandwidth for Intra String Copy mainly due to the reason that the memory fetch patterns in conventional video codec assumes rectangle blocks (e.g., 2x8, 4x4) and one string may take arbitrary fragments of multiple (e.g., 2) rows.

Assume we have an agreeable evaluation method for the memory access of Intra String Copy, this tool may be justified only if both higher coding efficiency (than that presented in this document) can be demonstrated and memory bandwidth access can be reduced to a level similar to other existing Intra coding tools, such as Intra BC.

# Patent rights declaration(s)

**Qualcomm Incorporated may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**

# References

1. Y. Chen and J. Xu, “Description of Core Experiment 10 (CE10): Intra String Copy”, JCT-VC Document, JCTVC-R1110, Sapporo, Japan, June 2014.
2. B. Li and J. Xu, “SCCE4: Result of Test 3.1”, JCT-VC Document, JCTVC-R0098, Sapporo, Japan, June 2014.
3. F. Zou, Y. Chen, J. Sole, M. Karczewicz, “SCCE4: Test 3.2 Pixel based 1D dictionary coding”, JCT-VC Document, JCTVC-R0140, Sapporo, Japan, June 2014.
4. F. Zou, Y. Chen, J. Sole, M. Karczewicz, “Non-SCCE4: Constrained run for 1D dictionary”, JCT-VC Document, JCTVC-R0225, Sapporo, Japan, June 2014.
5. Y. Chen and J. Xu, “BoG on 1D dictionary”, JCT-VC Document, JCTVC-R0336, Sapporo, Japan, June 2014.
6. H. Yu, R. Cohen, K. Rapaka, J. Xu , “Common conditions for screen content coding tests”, JCTVC-R1015, Sapporo, Japan, June 2014.