Improved Video Coding Technique for Next Generation Communication System

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Abstract —Traffic information on 5G mobile system network predicts to be dominated by demanding video services in real time and broadcasting application, and high video quality transfer. The most prediction of 5G systems is that they are going to be capable of handling high-definition like 4K and 8K video streaming which these are going to deliver facilities that are gathering the necessities of the client recognize quality by assurance quality. This paper aims to find the most effective kind of the latest video standard scalable that supports high-definition video, like H265, H264, and VP9. Furthermore, the paper also implements the control of the best video standard scalable by employing RDO to choose the best coding comparison mode. The paper used the parameter such as bit rate, PSNR for evaluation purposes. Finally, the result shows that H265 is better regarding data consumption, which is equal to 49.61% and 22.61% compared to AVC and VP9. At the same time, it also provides high quality. Saving bit rate lead to increase the number of users. Finally, the paper is compared a different mode of the types in HEVC to select the optimal mode that it achieved the compression with low bit rate and high PSNR

Index Terms—5G, HEVC; AVC; VP9, 8K, 4K, PSNR

I. INTRODUCTION

High-Efficiency Video Coding (H.265/HEVC) was estimated to decrease the rate of the bit compared to Advanced Video Coding (AVC) while maintaining similar quality [1].

A new video compression scalable like a High Efficiency Video Coding (HEVC) [2] and the accessibility of High-Definition handy client's devices may require additional HD evolution in traffic of mobile video. Several tablets already have resolutions of 8k probable in the 2020s.

HEVC established by professionals from ITU-T and ISO/IEC; standardization activity was begun from 2010 and available the essential version of coding standard in 2013[3].

Google has been emerging HEVC, especially for their video stream service for example YouTube. Google released VP8 and approved it for their services in 2010; the VP9 was released for improved coding efficiency 2013.

Recently, there has been an increase in the use of video service over IP networks [4], video services presently are approximate 73 % of all the traffic services are consumed across networks and are expected to consume 82% in 2021. Also, Mobile devices increasing bit rate to twice of IP fixed [5]. Also, as 5G mobile systems enter service [6], estimated higher bandwidths, improved reliability and lower delays, are possible to raise the video on demand over mobile system.

These days, the drift is to persistently provide expanded quality of video administrations to clients. For higher quality, it is essential to utilize high-performing encoders since the transmission capacity of the transmission line is constrained. Later codecs are more complex and require more time to encode video. It is unsatisfactory to spend a few hours compressing a brief video arrangement in High Definition (HD) [7].

Rate control is one of the principal critical coding instruments in video coding benchmarks. A rate control calculation, to begin with, distributes a bit budget to the gather of pictures, outlines, or the coding units depending on the level at which the rate control is being connected. The apportioned bit budget for each unit at its level is at that point utilized to calculate the demonstrate parameters, which in turn are utilized to encode the video for accomplishing the target bit rate. Within the hypothesis of video compression, the quantization step estimate primarily determines the degree of spatial detail held within the video [8].

II. RELATED WORK

Some investigators have considered performance HEVC, AVC, and VP9 in the video coding area established on two properties are subjective and objective quality and calculation approaches. While related AVC to HEVC, the HEVC is saving bit rate more than AVC in the same of the quality.

Authors showed [9] a performance assessment of H265, H264, and VP9 in relations of processing time. The outcome of this research is that h265 has above seven encoding times VP9. Alternatively, the encoding times of the VP9 is higher than the AVC[2].

Grois and *et al*. [7] are extended their estimate to a low latency [10], which is more appropriate for real-time applications, the result is the HEVC is savings average bit rate more than VP9. Rerabek showed [11] a subjective

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evaluation of AVC, HEVC and VP9 were achieved in to decide the actual video quality.

Amit and *et al*. [8] describe R-D model based taxonomy of various algorithms including the classification criteria. Another classification categorizes the rate control algorithms according to their fundamental principle and mechanisms.

The goal of this paper analyses and evaluates a high definition video resolution such as 4k and 8k in the coding efficiency that can be achieved by the use of the emerging H265 standard and compare this standard with H264and VP9 to find the best coding standard that correspond with a proposed advance communication system in the paper [12].

Furthermore, it implements different types of RDO in this video coding standard to find the best kind of optimization. The article is organized as follows. Section 2 refers to the advanced video coding, the features of the investigated video coding standards that contribute to the coding efficiency enhancement from one standard to the succeeding. The RDO method in HEVC is discussed in Section 3. Section 4 implements the video coding standard by using video coding tool standards. The video standard results measurement such as bit rate saving and PSNR are provided in Section 5. Finally; Section 6 concludes the paper.

III. Advance Digital Video Coding

Video of the digital is a discrete format of actual pictures with sampling in two domain are temporal and spatial. In the domain of the temporal samples frames per second(F/S). Each frame is composed of pixels finite via spatial dimensions.

The pixels number for each frame is enormous. Hence, the storage and transmission of the digital video disgusted an excessive amount of space and bandwidth [13].

The compression methods are used to reduce the video bandwidth requirements. The video term coding is compressed and decompressed with the technique as shown in Fig. 1.

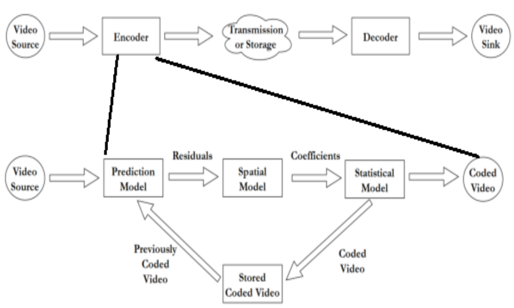

Fig. 1. Video coding processing.

Video transcoding is that the method of changing compressed video signals to adapt video characteristics like video bitrate, video resolution, or video codec, to satisfy the specification of communication channels and end devices.

Prior transcoding techniques are suitable for advanced video standards coding like AVC and HEVC has conferred new compression ideas, e.g., the quad-tree-based block structure, that is primarily wholly different from those in previous standards. These ideas want existing transcoding techniques to be custom-made and novel solutions to be developed [11]. The focus of this study is on transcoding for bit rate saving.

A. H.264(AVC)

This coding video type that the preferred compression familiar [14]. It used in the different video of applications from the mobile phone to internet applications to the HDTV. Variety of the practicality improvements inside AVC compared to preceding codecs of video are the discrete cosine transformation (DCT) works from 4*4 to 8*8, color sampling is compatible 12 bits/pixel. The Motion Compensation (MC) blocks, Arithmetic of Variable-Length Coding (VLC) is a type of the coding, De-blocking filter, as shown in Fig. 2, and the picture reference block, frequency distortion optimizer, Redundant Pictures (RD); B frame used direct mode, multiple reference frames, and sub-pixel used MC [11].

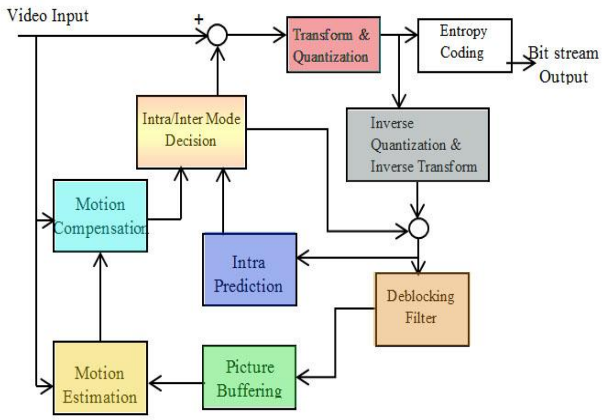

Fig. 2. AVC encoder block diagram.

B. H.265(HEVC)

The HEVC the coded data of video. It produces arrangements that are recorded inside data of the units called the Network Abstraction Layer (NAL) [12].

HEVC has the same H.264 coding structure. Nevertheless, HEVC has various enhancements such as flexibility division partitions and transforming block sizes, more interpolation that is a complicated and unblocking filter, as shown in Fig. 3, a prediction that is new complicated and Motion Vector (MV), and supports economic multiprocessing[14]–[16]. Within the following, the different options concerned in hybrid video coding using H.265/HEVC highlighted as follows:

- A different form of structure coding like coding tree units (CTU), coding tree block (CTB), coding units (CUs), coding blocks (CBs), prediction units (PUs) and prediction blocks (PBs).
- Transform units (TUs) and transform blocks (TBs),
- Different MV signaling,

- Quantization control,
- In-loop de-blocking filtering,
- Sample adaptive offset (SAO).

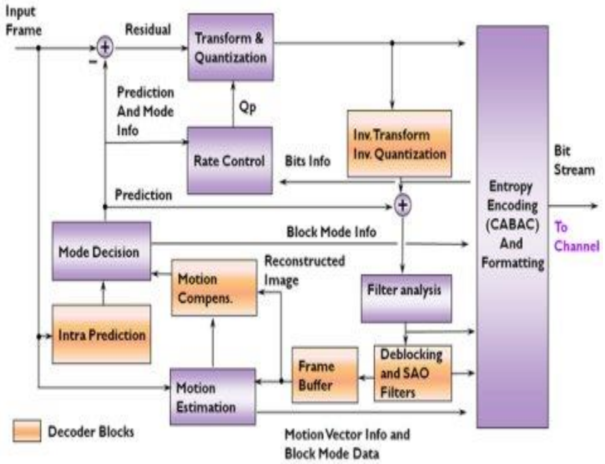

Fig. 3. HEVC encoder block diagram

C. VP9 Encoder

The VP9 encoder as shown in Fig. 4, it uses a two-pass of coding that enhances Rate-Distortion (RD) performance. Input frame video is measured in first. The enchantment of rate-distortion is occurred in the second stage, thereby completing a significant reduction in the bit rate for the same video quality. The encoding system of the complete video sequence has to be achieved out double. Furthermore, since the second pass encoding was used the progress and testing of VP9 [8], the VP9 has several features are only working for the two -pass coding.

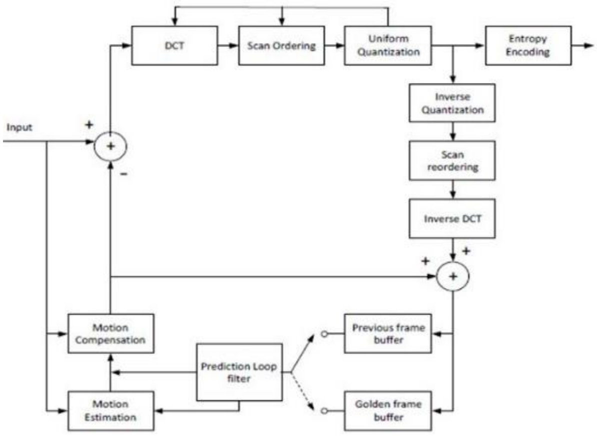

Fig. 4. VP9 encoder block diagram.

VP9 uses ten types of prediction frame techniques, which can permit rectangle coding. The post-processing in VP9 implements a de-blocking filter. VP9 encoder can make the balance of speed coding and quality encoding via choosing factors of quality and CPU to consume [14], [17]. Table I shows the video standard features.

TABLE I. ADVANCE VIDEO STANDARDS FEATURES

	H.264/AVC	HEVC	VP9
Partition size	Macroblock 16x16	Coding Unit 8x8, 64x64	Superblock 64x64
Transform	DCT 8x8, 4x4	TU square IDCT from 32x32 to 4x4 + DST Luma Intra 4x4	Transform block32x32 to 4x4
Intra prediction	Up to 9 predictors	35 predictors	Ten predictors
Entropy coding	CABAC, CAVLC	CABAC	Arithmetic coding 8 bit

IV. RATE-DISTORTION OPTIMIZATION (RDO) IN HEVC

Rate-Distortion Optimization is an essential method in the coding of the video. RDO is established on the Lagrange optimization procedure, the optimal parameters that mean the trade-off between distortion and rate can be accomplished. The prediction modes in HEVC are much more complicated than in AVC. Low precision fast RDO is used in other AVC coding established on the estimation of distortion and bit rate. The quality decision, however, is quite low, Fig. 5. Explains the block diagram of the RDO. The part in dashed line means rate distortion calculation, while the grey line displays the latency distortion. The rate is counted up afterward the quantizing step is entropy coded. Also, the distortion is considered after the block restored and it related to the original pixels. In H265 intra mode prediction, the PU able differ from 4x4 to 64x64. Per PU, some candidate prediction modes are chosen from all modes of the directional [18].

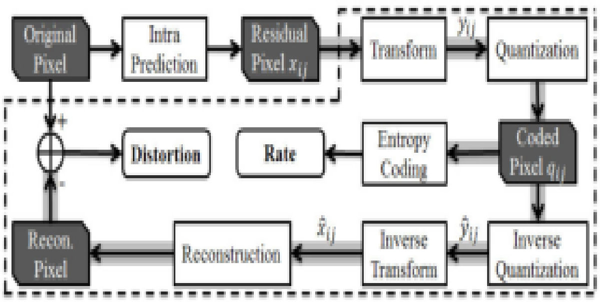

Fig. 5. RDO in HEVC.

V. THE IMPLEMENTATION OF VIDEO CODECS

The hybrid, IFME, and FFMPEG selected as a tool, as it is a simplified implementation video standard coding. For each video coding, the set of fixed quality is separate; like an adjuster, comparison setting allows as it eliminates all adaptation of the control rate between video sequences. The test video sequences were used in the tests, with various temporal and spatial features, frame rates and resolutions, which are denoted by class A, B, C and D. according to the resolution, as presented in Table II. Raw is kept for each video sequence resolution with 8 bits /sample. Additionally, each sequence frame was encoded with a different of the codecs are HEVC, AVC, and VP9.

Additional, for each of these sequences, consist from 9053 frames. Also, the sequences were mostly carried out on laptops with Intel Core i7 CPU, 2.4 GHz, 8GB RAM.

The video design follows the classic block-based hybrid video coding approach as shown in Fig. 6. The basic source-coding algorithm is a hybrid of interpicture prediction to exploit temporal statistical dependences, intrapicture prediction to exploit spatial statistical dependences and transform coding of the prediction residual signals to exploit spatial statistical dependencies further.

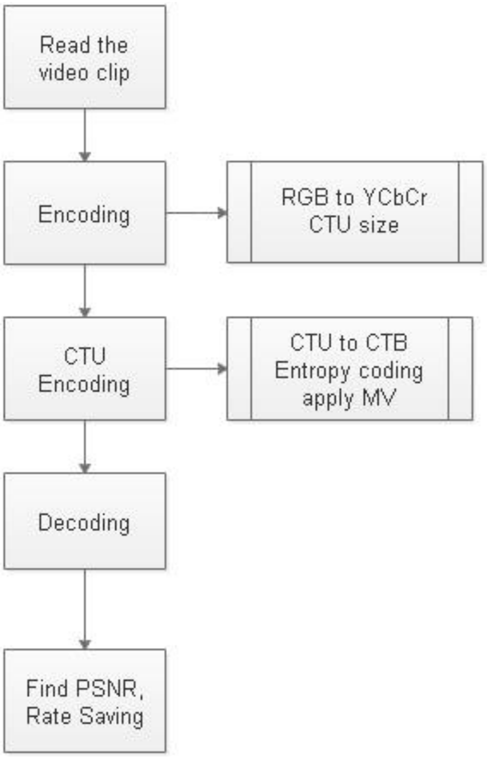

Fig. 6. Block diagram of video coding simulation.

TABLE II. VIDEO SEQUENCES PARAMETERS

Class Resolution	Resolution	Dimension	Frame rate
A	HD	1920*1080	30
B	QHD	2560*1440	30
C	4K	3840*2160	30
D	8K	7680*4320	60

VI. RESULT

Fig. 7. Presents a level bit rate of H265, H264, and VP9 encoders; the H265 offers significant gains regarding coding efficiency compared with VP9 and H264 encoders.

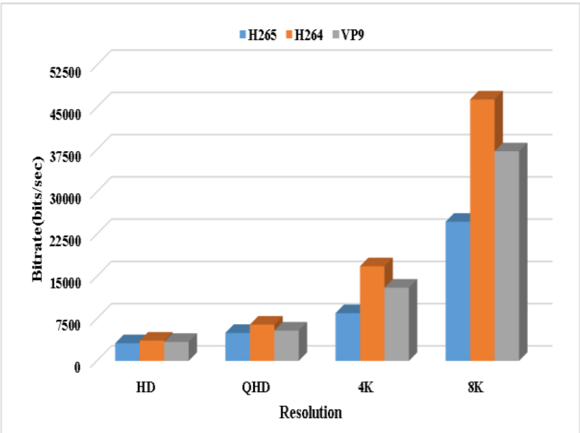

Fig. 7. Bitrate levels comparison.

The HEVC bit rate savings percentage is compared to AVC and VP9 in 8k is 46.76%, and 19.82 %, respectively, while the average bitrate saving in 4k is 49.61% and 22.61%, respectively, from these results presented that VP9 is more saving rate than AVC. Table III shows detailed results of the experimental, including the calculated bit rate savings for a different type of resolution.

Fig. 8. presents that the HEVC is the best PSNR from another standard because it used a more complicated filter, which is used the SAO and deblocking filter, these features lead to reduce artifact and increase the smoothness of the superiority of all types of resolution such as 8k and 4k.PSNR in H264 was equal 46.2 dB, and VP9 was 36.04 dB, which means the AVC more quality than VP9, PSNR parameter measured in the Eq. (1) moreover, Eq. (3), For more details of the compression results, as observed in Table IV.

$$MSE = \frac{1}{m*n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I_1(i,j) - I_2(i,j)]^2 \quad (1)$$

$$MSE\ avg = \frac{1}{N}\sum_{i=1}^{N} MSE_i \quad (2)$$

$$PSNR = 10 \cdot log10\ \frac{(2^B - 1)}{MSE\ avg} \quad (3)$$

where I_1 is the original image, I_2 is reconstruction image, m, n is the dimension of the image, and b is the number of bits per sample.

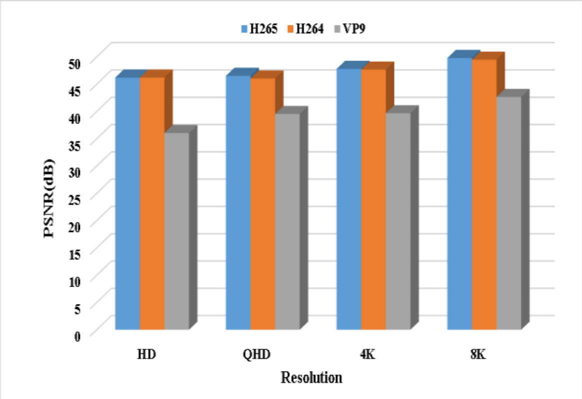

Fig. 8. Average PSNR levels comparison.

TABLE III. BITRATE VIDEO CODECS RESULT

Video standard	HD	QHD	4k	8k
H265	3132	4964	8465	24700
H.264	3597	6440	16800	46400
VP9	3374	5382	13000	37200

TABLE IV. PSNR VIDEO CODECS RESULT

Video standard	HD	QHD	4k	8k
H265	46.2	46.52	49.8	49.8
H.264	46.2	46.04	47.66	49.48
VP9	36.04	39.53	39.66	42.66

The result of RDO mode in HEVC as presented in Table V, the split decisions was the best because it provided bit rate saving and good quality.

TABLE V. RDO MODES RESULT

Level mode	Data Rate (kb/s)	PSNR (dB)
merge/skip selection	3959	45.446
splits and merge/skip selection	3199	45.818
split decisions	3132	45.973

VII. CONCLUSION

This paper evaluated advanced video compression standard in the high-resolution video such as 8k. According to the experimental results, the HEVC offered enhancements in the compression performance when compared it with AVC and VP9, because it is used parallel processing for large block frame and more flexibility partition of the blocks.

Result measurements present that the HEVC provided the bit rate savings at 4k be 49.61% and 22.61%relative to AVC and VP9 respectively. Regarding the quality, it is shown that the HEVC more PSNR than AVC and VP9, receptively, because it used a more complex de-blocking filter to enhance the quality. Also, the split decisions RDO mode was the best from others modes because this mode is less the bit rate and a high PSNR.

REFERENCES

[1] M. Wien, *High-Efficiency Video Coding - Coding Tools and Speci cations*, Berlin, Springer, 2014.

[2] J. Ohm, G. J. Sullivan, H. Schwarz, T. K. Tan, S. Member, and T. Wiegand, "Comparison of the coding efficiency of video coding standards — Including High-Efficiency Video Coding (HEVC)," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 22, no. 12, pp. 1669–1684, 2012.

[3] G. J. Sullivan, J. R. Ohm, W. J. Han, and T. Wiegand, "Overview of the high-efficiency video coding (HEVC) standard," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 22, no. 12, pp. 1649–1668, 2012.

[4] P. Hanhart, P. Korshunov, T. Ebrahimi, and M. Reˇ, "Quality evaluation of HEVC and VP9 video compression in real-time applications," May 2015.

[5] H. Y. S. Rezvani, S. Parsaeefard, N. Mokari, and M. R. Javan, "Delivery-Aware cooperative joint multi-bitrate video caching and transcoding in 5G," in *Proc. Mobile Computing (TMC)*, 2018, pp. 1–47.

[6] J. Nightingale, P. Salva-Garcia, J. M. A. Calero, and Q. Wang, "5G-QoE : QoE modelling for Ultra-HD video streaming in 5G networks," in *Proc. IEEE Transactions on Broadcasting*, 2018, pp. 1–14.

[7] J. Kufa and T. Kratochvil, "Software and hardware HEVC encoding," in *Proc. International Conference on Systems, Signals, and Image Processing*, 2017, pp. 1–5.

[8] A. A. Ramanand, I. Ahmad, and V. Swaminathan, "A survey of rate control in HEVC and SHVC video encoding," in *Proc. IEEE International Conference on Multimedia and Expo Workshops*, 2017, no. 7, pp. 145–150.

[9] D. Grois and A. Mulayoff, "Performance comparison of H . 265 /MPEG-HEVC, VP9, and," in *Proc. Pict. Coding Symp. IEEE*, 2013, pp. 394–397.

[10] D. Grois, D. Marpe, T. Nguyen, and O. Hadar, "Comparative assessment of H . 265 /MPEG-HEVC, VP9, and H . 264 / MPEG-AVC encoders for low-delay video applications," in *SPIE*, 2013, vol. 9217, no. 6.

[11] M. T. E. Reabek, "Comparison of compression efficiency between HEVC / H . 265 and VP9 based on subjective assessments," in *SPIE*, 2014, p. 92 170U--92 170U--13.

[12] S. K. Ibrahim and N. N. Khamiss, "Optimization a scheduling algorithm of CA in LTE ADV," *Telkomnika*, vol. 16, no. 6, pp. 2514–2521, 2018.

[13] S. Tamanna, "Transcoding H . 265 / HEVC Video," *Blekinge Institute of Technology Sweden*, 2013.

[14] A. Jassal, I. S. Member, C. Leung, and I. Member, "H . 265 video capacity over beyond-4G networks," in *Proc. Communication QoS, Reliability and Modeling Symposium*, 2016, pp. 1–6.

[15] M. Winken, P. Helle, and D. Marpe, "Transform coding in the hevc test model," in *Proc. IEEE International Conference on Image Processing*, 2011, pp. 3693–3696.

[16] M. Uhrina, J. Frnda, L. Sevcik, and M. Vaculik, "Impact of H . 264 / AVC and H . 265 / HEVC compression standards on the video quality for 4K resolution," *Adv. Electr. Electron. Eng. J.*, no. 12, pp. 368–376, 2014.

[17] L. Mengzhe, J. Xiuhua, L. Xiaohua, and A. E. Configuration, "Analysis of H . 265 / HEVC , H . 264 and VP9 coding efficiency based on video content complexity,"

in *Proc. IEEE International Conference on Computer and Communications*, 2015, pp. 420–424.
[18] Z. Sheng, D. Zhou, H. Sun, and S. Goto, "Algorithms for HEVC Intra Prediction," in *Proc. International Conference on Multimedia Modeling*, 2014, pp. 541–552.

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