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# Optimal quality ultra high video streaming based H.265

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**ABSTRACT**

Using Ultra-High Definition (UHD) video streaming in real-time transmission over the internet is the main challenge of this paper. Due to the widely variation of the available Internet bandwidth makes the difficulties of video streaming with flexibility and efficiency. In this paper the UHD video is down sampled and encoded at different levels of 4K, FHD, 720p, 4CIF, CIF and QCIF. Experiments were done to find the optimal configuration of H265 features at each level that give the required PSNR, 36 dB, at assigned bitrate. A controller is incorporated with H265 encoder to achieve the adaptation of video streaming on the available bandwidth by choosing the proper level that is compatible with the channel bitrate results of keeping a good quality to the end user. The adaptation of video was realized by making the controller periodically reads the status of the buffer, such function helps the controller to select the proper level, 4K, FHD, 720p, 4CIF, CIF or QCIF to be streamed over the channel. At the decoder the reconstructed video for lower level is done by interpolation scaling up.



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## 1. INTRODUCTION

The Variety of services and increase using of video streaming with different resolution for several kinds of terminal devices like mobile, tablet, personal PCs and HDTV, is the main challenge of multimedia providers. In the recent years, the transition formats is from SD (Standard Definition) to HD (High Definition) then the formats are developed continuously to UHD (Ultra-high Definition) [1]. The ISO/IEC and ITU-T are standardization organizations, they were worked together in the collaboration name (JCT VC) to produced H.265 in January 2013 [1], the H.265 is also called HEVC (High Efficiency Video Coding) as ISO/IEC 23008-2 (MPEQ-H, Part2) and ITU-T Recommendation (H.265). The main goal of this technique is to improve compression performance with good quality of bit-rate that reduction more than 50% from the previous stander [2]. Moreover, H.265/HEVC have greater flexibility and more sophisticated features that can enable better compression and possible to store or transmit video more efficiency than H.264/MPEG-4 AVC.

The diversity of services and devices with growing popularity of higher quality UHD video in mobile applications, make the compression techniques with H.265/HEVC encoders [3] is the argent to get the better of the traffic bandwidth load balancing. The purpose of the paper is about video compression and video streaming adaptation [4] with the channel's bandwidth, where the internet is considered as the media communication channel for wide range terminal devices. The available bandwidth is the main challenges where unlimited number of users shared with. The H265 parameters that are directly effect on the bitrate and quality, like quantization parameter, constant rate factor, group of pictures, number of references and others are used to find the optimal bitrate and quality for each level. The HEVC is used to produce the compressed video at each level. Based on the channel buffer statues the controller selects the proper level. While the reconstructed video almost in the proper resolution based on the user terminal device application.

### 1.1. HEVC System

HEVC is used as the core part of the proposed encoder due its properties of coding efficiency, integration of transport system, flexibility of removing redundant data and designing of parallel processing [5]. Figure 1 describes the block diagram of HEVC encoder. In H.265/HEVC, the input frame was partitioned by using Coding Tree Unit (CTU) with sizes 8×8, 16×16, 32×32, 64×64 of macroblocks, HEVC partitioning is more flexible than previous stander because it's using larger size of block, each input frame of video is divided into square blocks is called Coding Tree Blocks (CTBs), and can be sub partitioning into smaller units, called Coding Unit (CU), the CU is represents the root for Prediction Unit (PU) or (Transform Unit (TU)[6]) [3], see that in Figure 2. There are three types of PU splitting: skipped, intra and inter coded [3], see Figure 3. The TU having coefficients that using for applying the transform and quantization processes, these coefficients are transmit to the decoder after quantization process [7].

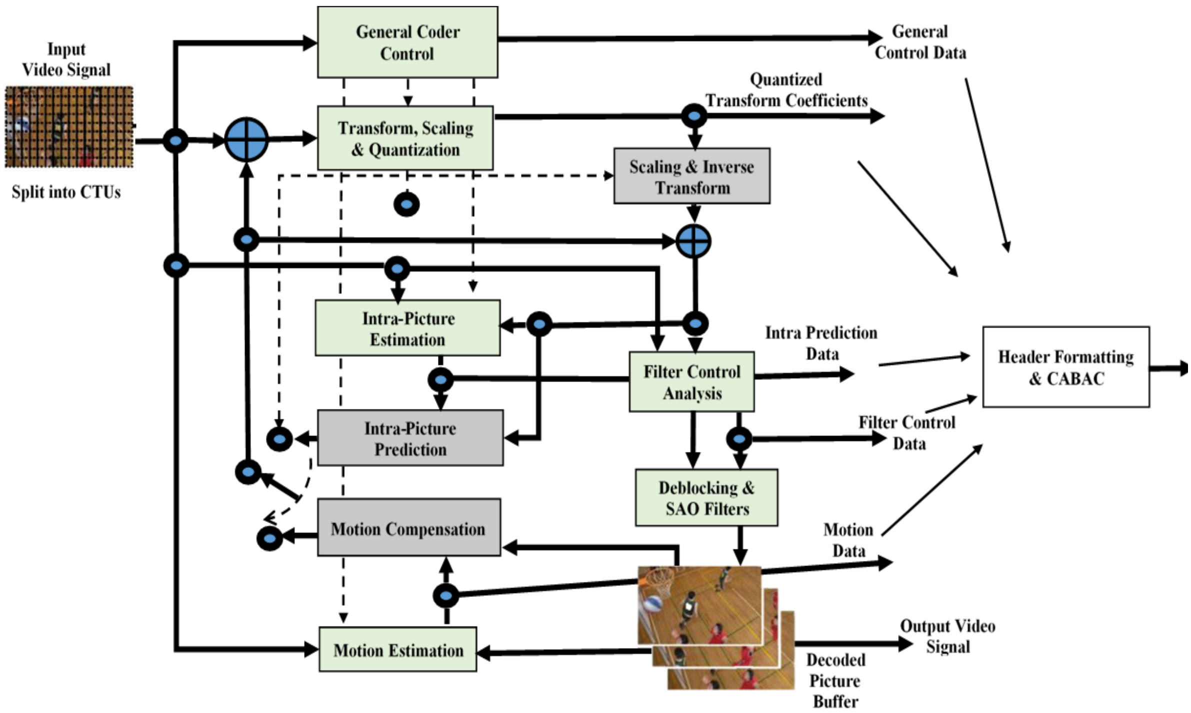



Figure 1. Block diagram of H265 encoding [5]

The technique of macroblock partitioning can be used in prediction process, there are two types of prediction (intra and inter [8]), this applying to minimize data redundancy [3]. The inter prediction include motion data that involve motion vector (MV) and the reference picture which was selected for predicting [1]. Then the prediction values subtracted from the original data to produce residual signal, then its transform by Discrete-Cosine Transform (DCT) [9] algorithm to convert spatial domain into frequency domain that produce the transform coefficients to be scaled [1], then applying the quantization process on it to lose inadequate information, while the efficiency of compression was affected directly by quantization process in term of rate distortion [10], and then applying SBAC (syntax-based context-adaptive binary arithmetic coder) entropy coding [11] to get compressed bitstream and then transmit with side information over the channel.

After DCT and quantization processes, the data loss occurs [3]. The coefficients from transformed and quantized pass throw Dequantization and inverse DCT to restore residuals, then was summed with prediction values to obtain restored pixel values, and this values are used in intra-prediction with current frame of video [3], the results from this operations pass throw the post-processing, there are two kinds of post-processing: Sample Adaptive Offset (SAO) and Deblock Filter (DBF), are using to reduced image blockiness that resulting from DFT and quantization processes. Then the restored value and post-processed frame is saved into Decoded Picture Buffer (DPB) that using for inter prediction of more frames [3].

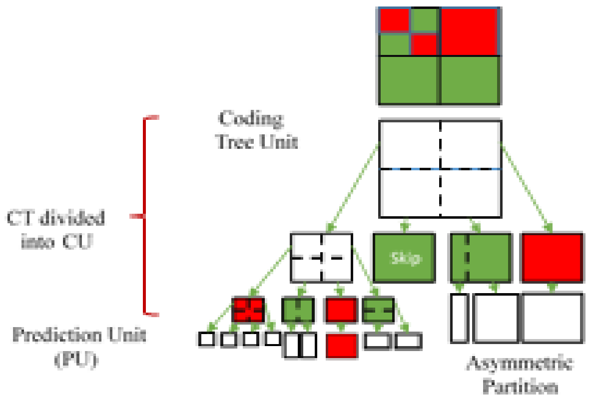



Figure 2. Coding tree unit method [12]

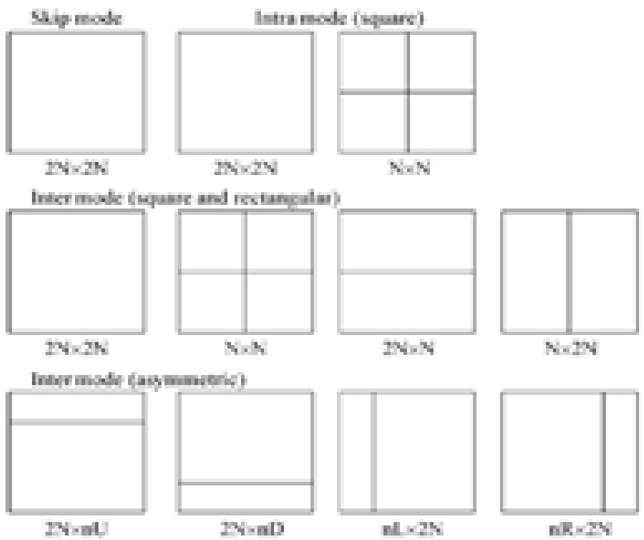



Figure 3. PU with three splitting types [7]

## 2. THE PROPOSED SYSTEM

The proposed system is mainly consists of the controller incorporated with encoder described in A. Such system will serve the bandwidth reservation for video streaming with UHD resolution especially for widely usage Internet, also unexpected number of users at the channel cause a variation of bandwidth availability, all that reasons generates a congestion in the network which make the status of channel is bad. To eliminate this problem there is a controller using to avoid congestion when the network is loaded.

In this paper UHD (4K) is the goal. H.265 encoder with its features and parameters that effect on BR and PSNR are used to find the optimal value of them for different formats. The raw video, 4K “3840*2160”, is subsampled into the other formats, 1080i/p “1920*1080”, 720p “1280*720”, 4CIF “704*576”, CIF “352*288”, QCIF “176*144”, see Figure 4. As parallel process all formats are encoded with H265 make the control terminal selects the proper format based on channel buffer status. As design steps, each of these formats is worked of optimal BR and PSNR. When the channel is busy with number of users at a time, the video sequence should be transmit with one of these formats be less than UHD.

While at video reconstruction at the fare terminal side, there are two strategies, if the terminal device was viewing his video with UHD so when video was received with lower than UHD format it should be submitted into up subsampling or the interpolation process to retrieve his format viewing. But if the terminal is using applications with different formats, it will be updated to be proper to that format, which is closer to the scalability situation. Adapting the sending bitrate over internet [13] needs to modify the syntax of network layer to include the transmitted format.

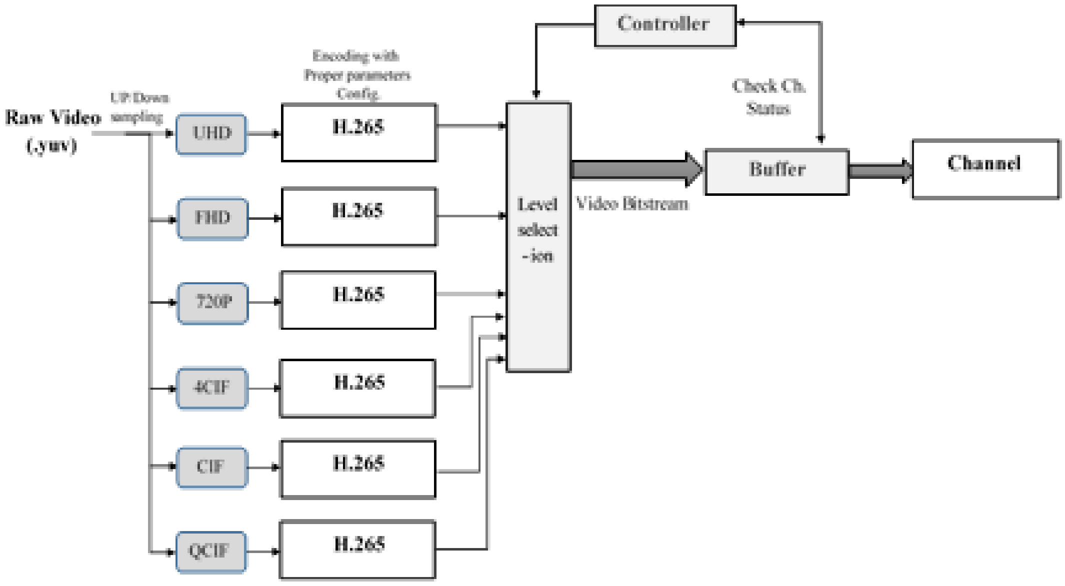



Figure 4. The controller was used to select proper format

## 3. RESEARCH METHOD

The varying of the available bandwidth needs the adaptation of video bitrate and quality as a status of channel. The variation of video resolution based on the encoder and controller to produce the compressed video streaming in the source that which appropriate with an available bandwidth. HEVC encoder with its features configuration can obtain the optimal video encoded for each of the used formats.

In this work using open source software is “ffmpeg” to apply encoding over three test sequences with changing the basic parameters that which directly effect on the bitrate (Measuring of Bit Rate [14]) and quality of videos. The Peak Signal to Noise Ratio (PSNR) is using to represent the measuring of quality of video. The ffmpeg is a collection of libraries and tools to process multimedia content such as audio, video, subtitles and related metadata. In this work using libx265 and libavcodec that provides implementation of a wider range of codecs, also using ffmpeg tools to manipulate, convert and stream a video.

For each format the “H.265” encoder is applying by ffmpeg software on raw video in uncompressed form (yuv) using the system parameters, these parameters like QP, CRF, GOP and REF are changing to obtain more compression ratio according to the details of the video. The Quantization Parameter (QP) is one of the most important parameter in the HEVC encoding, quantization process doing as a key role for improve the performance of encoder. At the higher value of QP the redundancy details of video was removed results of high compression, but with low value of QP make more details in background and more consumption of bit and partitioning [15]. The Constant Rate Factor (CRF) [4] is working as a control on the adaptive quantization parameter [16] to obtain constant quality that applying across frames of changing motion and complexity, the default range of CRF values 0-51, there is a lossless quality at 0 that needing greatest bit rate, and at 51 there is a most loss of quality but obtaining least bit rate. Increasing the value of CRF by 6 an approximately results half value of the bit rate [17].

The group of pictures (GOP), the scalable video sequence is divided into GOPs and each one content three types of frames I,P,B. GOP is one of the most important parameter to get video with good quality and lower bitrate, the structure of GOP was represented by a number referred to distance between two frames (I or P). The size of GOP can be change and it’s dependent on the details of video’s motion and information, the higher compression ratio was reached when the GOP was increased [18]. For reference picture [19] in HEVC, there are two types of prediction (intra and inter), intra prediction doesn’t based on a reference picture in there prediction it just based on the same picture. Inter prediction based on different number of pictures and using MV (motion vectors [20]) to decide each part that using from reference picture for prediction. HEVC having three kinds of slice: (intra “I”, predictive “P” and bi-predictive “B”), at the decoder when it decoding a P or B slice put up lists of reference picture for the slice to be encoding. There are two types of lists L0 and L1, the P and B slices using L0 but L1 just for B slice [21].

## 4. RESULTS AND ANALYSIS

The experimentation was proposed for three test sequences (HoneyBee, Jockey, ReadySetGo) with different details and motions. This proposed work using six resolutions of these sequences, each sequence has 600 frames (100 frames are encoded) with frame rate 120 fps (frames per second), the videos are in uncompressed form (yuv). When applying the default parameters of H265 encoder, the first video “HoneyBee”, it have low motion details, so the compression ratio is higher than two other video because there are more information redundant in frames of sequence must be encoded by compression process, the second video “Jockey” having medium motion details so the value of compression ratio is less than the first, while the last one “ReadySetGo” video have high motion details so the compression ratio is the least [22]. In Table 1 below, describe the ratio of compression for each video at the PSNR 36 dB with all formats. In Figure 5 is describe three test sequences that used in this work.

Table 1. The compression ratio with best PSNR of three video test sequences for six formats

| Video Name | | Honeybee | | | Jockey | | | ReadySetGo | |
|---|---|---|---|---|---|---|---|---|---|
| Size | PSNR (dB) | CR | Motion Details | PSNR (dB) | CR | Motion Details | PSNR | CR | Motion Details |
| 4K | 36.557 | 15072.16354 | Low | 36.921 | 6408.481733 | Medium | 36.86 | 1618.285751 | High |
| HD | 36.902 | 6581.406216 | | 36.277 | 2311.97417 | | 36.925 | 592.1775035 | |
| 720p | 36.54 | 4284.850833 | | 36.003 | 1350.123608 | | 36.638 | 344.9854946 | |
| 4CIF | 36.414 | 2419.01073 | | 36.605 | 598.3451173 | | 36.352 | 197.5228669 | |
| CIF | 36.749 | 853.9397485 | | 36.4 | 206.5087 | | 36.551 | 85.26827958 | |
| QCIF | 36.937 | 399.6386334 | | 36.415 | 81.63881619 | | 36.288 | 53.17800315 | |

(a) (b) (c)

Figure 5. Three test sequences (a) HoneyBee (b) Jockey (c) ReadySetGo [23]

### 4.1. Quantitation Parameter (QP)

In the following tables, the HEVC performance is confirmed with different values of QP is set with range {16, 20, 24, 28, 32, 36, 40, 44 and 48} with its convenience to their video test sequences and its information with six formats. In 6 tables below you can see the value of PSNR and Bitrate are decreased when the QP was increasing.

Table 2. QP impact on video quality and bit rate (kb/s) on 4K (3840, 2160) resolution

| Video Name | Honeybee | | Jockey | | ReadySetGo | |
|---|---|---|---|---|---|---|
| QP | PSNR(dB) | BitRate(kb/s) | PSNR(dB) | BitRate(kb/s) | PSNR | BitRate(kb/s) |
| 16 | 44.145 | 1222890.23 | 48.798 | 309306.97 | 45.168 | 700028.93 |
| 20 | 41.702 | 494996.55 | 46.939 | 139805.17 | 43.335 | 236142.47 |
| 24 | 40.28 | 108672.8 | 45.375 | 51133.58 | 42.211 | 74473.6 |
| 28 | 39.734 | 13200.13 | 44.179 | 19007.98 | 41.197 | 34367.93 |
| 32 | 39.313 | 3214.25 | 42.962 | 9696.57 | 39.966 | 19506.21 |
| 36 | 38.736 | 1920.44 | 41.437 | 5984.96 | 38.503 | 11963.12 |
| 40 | 38.002 | 1349.32 | 39.73 | 3789.32 | 36.86 | 7380.61 |
| 44 | 37.046 | 900.92 | 37.958 | 2339.92 | 35.113 | 4274.1 |
| 48 | 35.74 | 694.21 | 35.795 | 1502.54 | 33.238 | 2385.29 |

Table 3. QP impact on video quality and bit rate (kb/s) on 1080i/p (1920, 1080) resolution

| Video Name | Honeybee | | Jockey | | ReadySetGo | |
|---|---|---|---|---|---|---|
| QP | PSNR(dB) | BitRate(kb/s) | PSNR(dB) | QP | PSNR(dB) | BitRate(kb/s) |
| 16 | 45.089 | 117363.45 | 45.846 | 16 | 45.089 | 117363.45 |
| 20 | 43.643 | 24291.25 | 44.495 | 20 | 43.643 | 24291.25 |
| 24 | 42.806 | 4560.79 | 43.461 | 24 | 42.806 | 4560.79 |
| 28 | 41.954 | 1823.68 | 42.261 | 28 | 41.954 | 1823.68 |
| 32 | 40.825 | 1118.16 | 40.787 | 32 | 40.825 | 1118.16 |
| 36 | 39.398 | 759.96 | 39.042 | 36 | 39.398 | 759.96 |
| 40 | 37.779 | 538.58 | 37.203 | 40 | 37.779 | 538.58 |
| 44 | 35.936 | 387.09 | 35.29 | 44 | 35.936 | 387.09 |
| 48 | 33.93 | 288.64 | 33.257 | 48 | 33.93 | 288.64 |

Table 4. QP impact on video quality and bit rate (kb/s) on 720p (1280, 720) resolution

| Video Name | Honeybee | | Jockey | | ReadySetGo | |
|---|---|---|---|---|---|---|
| QP | PSNR(dB) | BitRate(kb/s) | PSNR(dB) | QP | PSNR(dB) | BitRate(kb/s) |
| 16 | 45.8 | 22831.75 | 46.518 | 16 | 45.8 | 22831.75 |
| 20 | 44.504 | 4416.19 | 45.096 | 20 | 44.504 | 4416.19 |
| 24 | 43.384 | 1708.52 | 43.625 | 24 | 43.384 | 1708.52 |
| 28 | 42.099 | 1006.48 | 41.901 | 28 | 42.099 | 1006.48 |
| 32 | 40.403 | 657.97 | 39.995 | 32 | 40.403 | 657.97 |
| 36 | 38.519 | 446.71 | 37.989 | 36 | 38.519 | 446.71 |
| 40 | 36.54 | 309.72 | 36.003 | 40 | 36.54 | 309.72 |
| 44 | 34.46 | 218.55 | 33.966 | 44 | 34.46 | 218.55 |
| 48 | 32.336 | 153.93 | 31.887 | 48 | 32.336 | 153.93 |

Table 5. QP impact on video quality and bit rate (kb/s) on 4CIF (704,576) resolution

| Video Name | Honeybee | | Jockey | | ReadySetGo | |
|---|---|---|---|---|---|---|
| QP | PSNR(dB) | BitRate(kb/s) | PSNR(dB) | QP | PSNR(dB) | BitRate(kb/s) |
| 16 | 46.162 | 4271.15 | 46.592 | 16 | 46.162 | 4271.15 |
| 20 | 44.642 | 1684.38 | 44.811 | 20 | 44.642 | 1684.38 |
| 24 | 43.15 | 936.01 | 42.893 | 24 | 43.15 | 936.01 |
| 28 | 41.363 | 607.99 | 40.792 | 28 | 41.363 | 607.99 |
| 32 | 39.233 | 403.84 | 38.655 | 32 | 39.233 | 403.84 |
| 36 | 37.019 | 269.78 | 36.605 | 36 | 37.019 | 269.78 |
| 40 | 34.906 | 182.83 | 34.586 | 40 | 34.906 | 182.83 |
| 44 | 32.762 | 126.33 | 32.537 | 44 | 32.762 | 126.33 |
| 48 | 30.664 | 87.77 | 30.432 | 48 | 30.664 | 87.77 |

Table 6. QP impact on video quality and bit rate (kb/s) on CIF (352,288) resolution

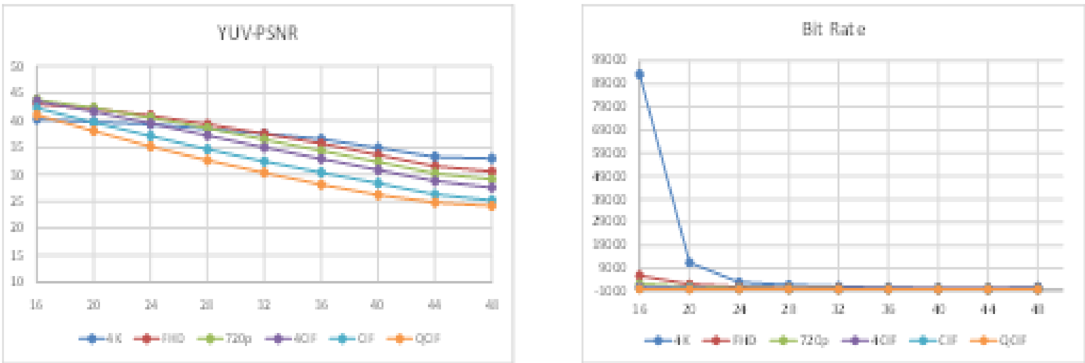
| Video Name | Honeybee | | Jockey | | ReadySetGo | |
|---|---|---|---|---|---|---|
| QP | PSNR(dB) | BitRate(kb/s) | PSNR(dB) | QP | PSNR(dB) | BitRate(kb/s) |
| 16 | 46.017 | 1297.64 | 45.992 | 16 | 46.017 | 1297.64 |
| 20 | 43.67 | 681.76 | 43.53 | 20 | 43.67 | 681.76 |
| 24 | 41.505 | 399.79 | 41.125 | 24 | 41.505 | 399.79 |
| 28 | 39.189 | 257.78 | 38.705 | 28 | 39.189 | 257.78 |
| 32 | 36.749 | 170.95 | 36.4 | 32 | 36.749 | 170.95 |
| 36 | 34.35 | 113.57 | 34.231 | 36 | 34.35 | 113.57 |
| 40 | 32.255 | 78.9 | 32.186 | 40 | 32.255 | 78.9 |
| 44 | 30.161 | 55.8 | 30.19 | 44 | 30.161 | 55.8 |
| 48 | 28.232 | 40.92 | 28.245 | 48 | 28.232 | 40.92 |

Table 7. QP impact on video quality and bit rate (kb/s) on QCIF (176,144) resolution

| Video Name | Honeybee | | Jockey | | ReadySetGo | |
|---|---|---|---|---|---|---|
| QP | PSNR(dB) | BitRate(kb/s) | PSNR(dB) | QP | PSNR( dB) | BitRate(kb/s) |
| 16 | 45.642 | 537 | 45.237 | 16 | 45.642 | 537 |
| 20 | 42.799 | 274.01 | 42.414 | 20 | 42.799 | 274.01 |
| 24 | 40.229 | 152.98 | 39.72 | 24 | 40.229 | 152.98 |
| 28 | 37.64 | 100.43 | 37.059 | 28 | 37.64 | 100.43 |
| 32 | 34.954 | 69.48 | 34.64 | 32 | 34.954 | 69.48 |
| 36 | 32.4 | 49.21 | 32.366 | 36 | 32.4 | 49.21 |
| 40 | 30.208 | 36.21 | 30.29 | 40 | 30.208 | 36.21 |
| 44 | 28.073 | 28.63 | 28.229 | 44 | 28.073 | 28.63 |
| 48 | 26.149 | 22.72 | 26.374 | 48 | 26.149 | 22.72 |

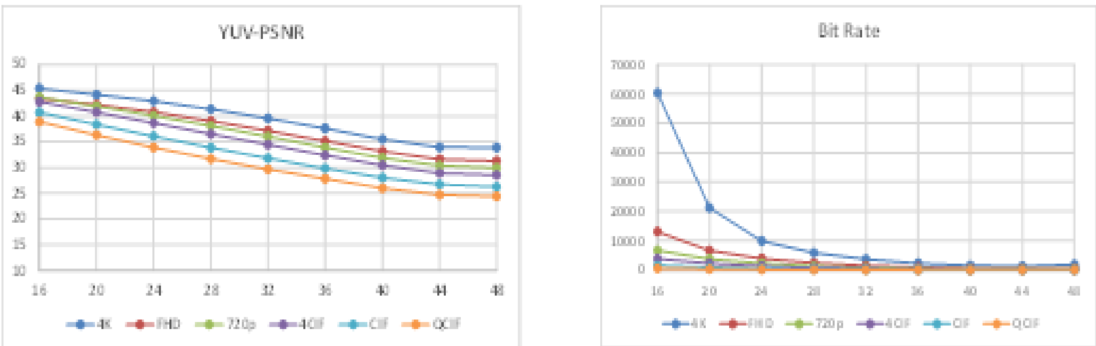
## 4.2. Constant Rate Factor (CRF)

The value of CRF was used in this work with range: {16, 20, 24, 28, 32, 36, 40, 44 and 48} and then comparison the results with video before encoding (raw data), see the results in charts below with all six formats for the three test sequences. When increasing the value of CRF the value of PSNR and BR was decreased.



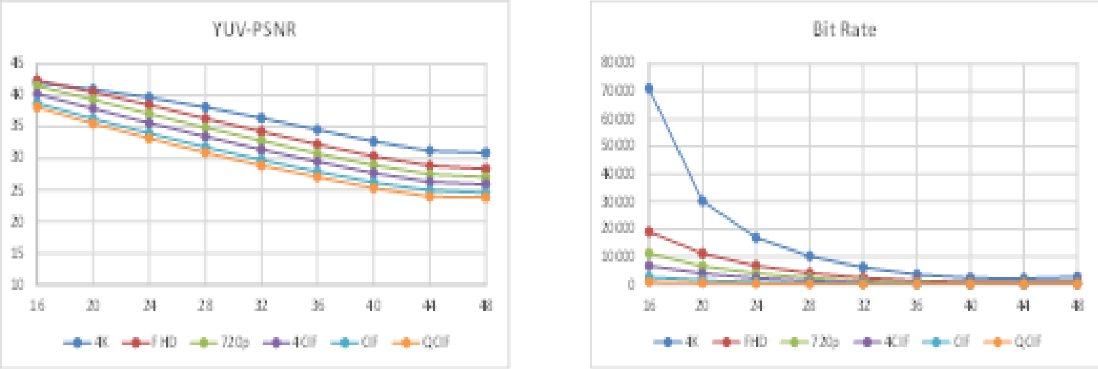

(a) YUV-PSNR (b) Bit Rate

Figure 6. HoneyBee video sequence and the variation of YUV-PSNR and bit rate according to CRF value with six resolutions




(a) YUV-PSNR (b) Bit Rate

Figure 7. Jockey video sequence and the variation of YUV-PSNR and bit rate according to CRF value with six resolutions




(a) YUV-PSNR (b) Bit Rate

Figure 8. ReadySetGo video sequence and the variation of YUV-PSNR and bit rate according to CRF value with six resolutions

### 4.3. Qroup of Pictures (QOP)

The ffmpeg open source software having default value of GOP is 250, in this paper using GOP range: (10, 20, 30, 40, 50, 60, 70, 80, 90, 100), it was denoted by (Keyint) and refers to the length of GOP, when GOP length was high the result of compression will more efficient, see tables bellow for three test sequences. In Table 8 at 4k resolution show the value of PSNR is 36 dB, when increasing the GOP length is that mean the number of GOP in on sequence was decreased so the value of PSNR and BR was decreasing.

Table 8. GOP impact on video quality and bit rate (kb/s) on HoneyBee test sequence

| GOP | 4K (3840,2160) | | | 1080i/p (1920,1080) | | | 720p (HDTV) (1280 × 720) | | |
|---|---|---|---|---|---|---|---|---|---|
| | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) |
| 10 | 46 | 36.78 | 3544.33 | 44 | 36.399 | 2044.25 | 40 | 37.042 | 1893.61 |
| 20 | 46 | 36.671 | 2012.97 | 44 | 36.224 | 1122.99 | 40 | 36.861 | 1009.24 |
| 30 | 46 | 36.649 | 1705.11 | 44 | 36.173 | 935.29 | 40 | 36.808 | 834.52 |
| 40 | 46 | 36.624 | 1402.46 | 44 | 36.128 | 754.31 | 40 | 36.749 | 658.81 |
| 50 | 46 | 36.59 | 1098.02 | 44 | 36.069 | 568.13 | 40 | 36.685 | 484.01 |
| 60 | 46 | 36.601 | 1100.1 | 44 | 36.057 | 569.88 | 40 | 36.686 | 482.65 |
| 70 | 46 | 36.601 | 1099.31 | 44 | 36.051 | 569.34 | 40 | 36.66 | 484.37 |
| 80 | 46 | 36.601 | 1098.57 | 44 | 36.043 | 570.4 | 40 | 36.648 | 484.54 |
| 90 | 46 | 36.594 | 1099.62 | 44 | 36.017 | 573.07 | 40 | 36.622 | 485.74 |
| 100 | 46 | 36.557 | 792.45 | 44 | 35.936 | 387.09 | 40 | 36.54 | 309.72 |
| GOP | 4CIF (704,576) | | | CIF (352,288) | | | QCIF (176,144) | | |
| | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) |
| 10 | 37 | 36.946 | 1569.8 | 32 | 37.41 | 1174.68 | 29 | 37.828 | 632.48 |
| 20 | 37 | 36.751 | 830.11 | 32 | 37.258 | 615 | 29 | 37.575 | 331.66 |
| 30 | 37 | 36.702 | 681.12 | 32 | 37.228 | 504.72 | 29 | 37.476 | 270.84 |
| 40 | 37 | 36.651 | 535.85 | 32 | 37.092 | 392.46 | 29 | 37.408 | 210.72 |
| 50 | 37 | 36.547 | 387.63 | 32 | 37.033 | 280.77 | 29 | 37.311 | 150.53 |
| 60 | 37 | 36.568 | 387.85 | 32 | 37.04 | 280.9 | 29 | 37.296 | 150.64 |
| 70 | 37 | 36.547 | 386.53 | 32 | 36.983 | 281.34 | 29 | 37.268 | 150.66 |
| 80 | 37 | 36.538 | 388.68 | 32 | 36.91 | 281.9 | 29 | 37.165 | 150.95 |
| 90 | 37 | 36.503 | 388.87 | 32 | 36.879 | 283.24 | 29 | 37.087 | 151.8 |
| 100 | 37 | 36.414 | 241.39 | 32 | 36.749 | 170.95 | 29 | 36.937 | 91.32 |

Table 9. GOP impact on video quality and bit rate (kb/s) on Jockey test sequence

| GOP | 4K (3840,2160) | | | 1080i/p (1920,1080) | | | 720p (HDTV) (1280 × 720) | | |
|---|---|---|---|---|---|---|---|---|---|
| | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) |
| 10 | 46 | 38.414 | 3244.23 | 44 | 36.49 | 1805.27 | 40 | 37.126 | 1752.4 |
| 20 | 46 | 37.971 | 2467.02 | 44 | 36.188 | 1340.68 | 40 | 36.785 | 1316.39 |
| 30 | 46 | 37.736 | 2336.56 | 44 | 36.019 | 1250.71 | 40 | 36.621 | 1230.09 |
| 40 | 46 | 37.625 | 2186.44 | 44 | 35.872 | 1174.62 | 40 | 36.519 | 1154.83 |
| 50 | 46 | 37.331 | 2014.91 | 44 | 35.627 | 1091.05 | 40 | 36.319 | 1064.24 |
| 60 | 46 | 37.315 | 2006.35 | 44 | 35.648 | 1080.81 | 40 | 36.308 | 1061.27 |
| 70 | 46 | 37.287 | 2048.35 | 44 | 35.58 | 1090.99 | 40 | 36.269 | 1068.05 |
| 80 | 46 | 37.231 | 2016.72 | 44 | 35.53 | 1097.9 | 40 | 36.239 | 1066.81 |
| 90 | 46 | 37.145 | 2038.89 | 44 | 35.464 | 1088.09 | 40 | 36.158 | 1066.54 |
| 100 | 46 | 36.921 | 1863.77 | 44 | 35.29 | 999.77 | 40 | 36.003 | 982.95 |
| GOP | 4CIF (704,576) | | | CIF (352,288) | | | QCIF (176,144) | | |
| | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) |
| 10 | 36 | 37.72 | 1659.68 | 32 | 37.589 | 1144.14 | 29 | 37.74 | 666.24 |
| 20 | 36 | 37.362 | 1268.41 | 32 | 37.193 | 891.02 | 29 | 37.293 | 529.44 |
| 30 | 36 | 37.19 | 1185.77 | 32 | 36.965 | 852.61 | 29 | 37.075 | 512.08 |
| 40 | 36 | 37.096 | 1124.68 | 32 | 36.894 | 799.67 | 29 | 36.972 | 488.49 |
| 50 | 36 | 36.891 | 1047.63 | 32 | 36.691 | 752.63 | 29 | 36.709 | 466.21 |
| 60 | 36 | 36.885 | 1035.26 | 32 | 36.679 | 748.1 | 29 | 36.723 | 462.62 |
| 70 | 36 | 36.847 | 1051.44 | 32 | 36.661 | 753.18 | 29 | 36.691 | 468.69 |
| 80 | 36 | 36.85 | 1048.83 | 32 | 36.634 | 756.53 | 29 | 36.629 | 476.28 |
| 90 | 36 | 36.736 | 1053.31 | 32 | 36.541 | 758.5 | 29 | 36.611 | 472.87 |
| 100 | 36 | 36.605 | 975.9 | 32 | 36.4 | 706.9 | 29 | 36.415 | 447.03 |

Table 10. GOP impact on video quality and bit rate (kb/s) on ReadySetGo test sequence

| GOP | 4K (3840,2160) | | | 1080i/p (1920,1080) | | | 720p (HDTV) (1280 × 720) | | |
|---|---|---|---|---|---|---|---|---|---|
| | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) |
| 10 | 40 | 37.712 | 12841.9 | 40 | 35.639 | 5789.54 | 34 | 37.418 | 7051.33 |
| 20 | 40 | 37.407 | 9686.86 | 40 | 35.367 | 4216.2 | 34 | 37.104 | 5251.31 |
| 30 | 40 | 37.301 | 9000.39 | 40 | 35.26 | 3873.34 | 34 | 37.049 | 4814.05 |
| 40 | 40 | 37.221 | 8469.22 | 40 | 35.187 | 3602.39 | 34 | 36.916 | 4543.98 |
| 50 | 40 | 37.091 | 7913.8 | 40 | 35.069 | 3310.18 | 34 | 36.832 | 4181.97 |
| 60 | 40 | 37.089 | 7879.2 | 40 | 35.053 | 3299.4 | 34 | 36.828 | 4171.67 |
| 70 | 40 | 37.055 | 7946.19 | 40 | 35.045 | 3317.35 | 34 | 36.791 | 4198.2 |
| 80 | 40 | 37.039 | 7930.48 | 40 | 35.037 | 3313.05 | 34 | 36.795 | 4174.09 |
| 90 | 40 | 36.994 | 7884.02 | 40 | 34.998 | 3288.13 | 34 | 36.769 | 4146.29 |
| 100 | 40 | 36.86 | 7380.61 | 40 | 34.888 | 3030.42 | 34 | 36.638 | 3846.84 |
| GOP | 4CIF (704,576) | | | CIF (352,288) | | | QCIF (176,144) | | |
| | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) | QP | PSNR(dB) | BitRate(kb/s) |
| 10 | 32 | 37.31 | 5175.66 | 29 | 37.617 | 2805.27 | 28 | 37.407 | 1063.88 |
| 20 | 32 | 36.926 | 3921.83 | 29 | 37.181 | 2163.99 | 28 | 36.933 | 849 |
| 30 | 32 | 36.805 | 3651.84 | 29 | 37.065 | 2037.97 | 28 | 36.822 | 804.21 |
| 40 | 32 | 36.702 | 3438.84 | 29 | 36.94 | 1927.27 | 28 | 36.64 | 767.86 |
| 50 | 32 | 36.556 | 3200.24 | 29 | 36.783 | 1845.11 | 28 | 36.536 | 724.31 |
| 60 | 32 | 36.541 | 3187.23 | 29 | 36.795 | 1818.01 | 28 | 36.512 | 722.23 |
| 70 | 32 | 36.543 | 3195.84 | 29 | 36.779 | 1837.36 | 28 | 36.505 | 725.99 |
| 80 | 32 | 36.523 | 3191.53 | 29 | 36.74 | 1824.01 | 28 | 36.457 | 732.52 |
| 90 | 32 | 36.494 | 3169.74 | 29 | 36.7 | 1833 | 28 | 36.457 | 721.57 |
| 100 | 32 | 36.352 | 2956.24 | 29 | 36.551 | 1712.02 | 28 | 36.288 | 686.28 |

### 4.4. Reference Picture

In this proposed work with ffmpeg open source software change the number of L0 that impact on the work was performed in motion that effect on distortion and compression. It is denote by “ref” and the default amount is 3, the range was used (1, 2, 3, 4, 5 and 6) that applying with GOP 10 and 100 for six resolutions to three video sequences, see following graphs.

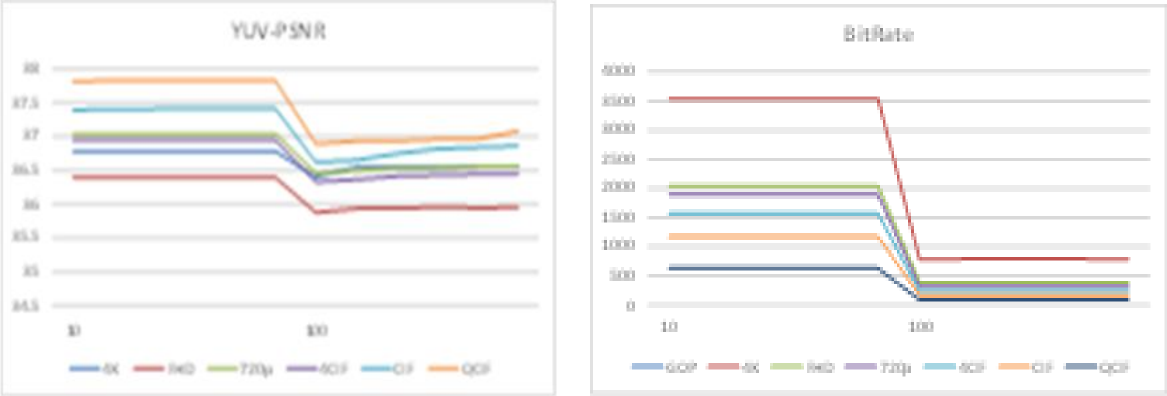
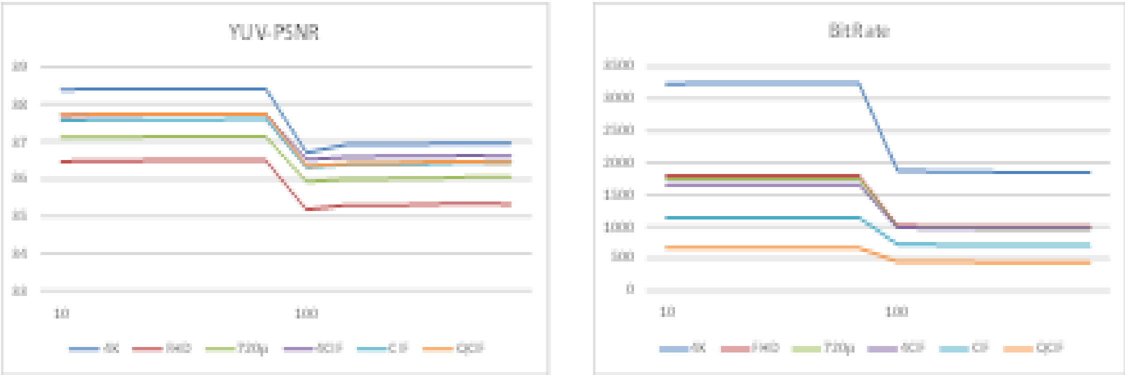
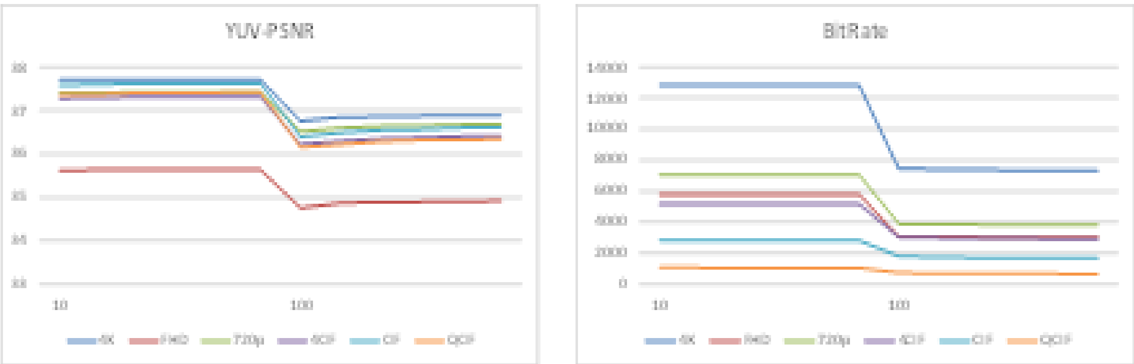



Figure 9. REF impact on video’s PSNR and bit rate (kb/s) on HoneyBee test sequence with six resolutions




(a) PSNR (b) BR

Figure 10. REF impact on video’s PSNR and bit rate (kb/s) on Jockey test sequence with six resolutions




(a) PSNR (b) BR

Figure 11. REF impact on video’s PSNR and bit Rate (kb/s) on ReadySetGo test sequence with six resolutions

### 4.5. Discussion

In the experiments of three types of test sequences in the previous section, we need to find the optimal configuration of encoder’s parameters of the source device with each resolution that can be applied on any video want to be transmitted over the channel. According to the results from encoded three videos the critical parameter for determining BR is QP. From changing the value of QP we conclude that the best rang 32-48, that keep the quality of video acceptable at the values (39-33) dB, also the impact of QP on bitrate. The same QP setting is applied on three different sequences having different motion details and bitrate. For example, encoding the Jockey video sequence at 4k resolution when the values of QP {32, 36, 40, 44 and 48} leading to accepted range of PSNR of encoded video to be transmit over the channel, also the BR with higher reduction value at 48 with less acceptable quality at 35 dB reached to compression ratio arrived to 7949, this scenario was performed with three test sequences for choose the optimal QP. But for saving PSNR and with decreasing BR can be used CRF parameter instead of QP, see Table 11 for both QP and CRF for 4K.

In consideration of conclusion above, it is possible to say that the bitrate was selected according to the buffer status, when the buffer is congested the selected bitrate should be small to be suitable with available bandwidth. The quality of video is change in direct proportion with the bitrate of video, when the bitrate was decreased that will lead to decreasing in the quality, the suitable selection of the GOP and REF can effectively improvement of the video quality with small bitrate. The larger GOP number and REF will result in better video quality. From these arguments can be decide what the optimal configuration of parameters are used, see Table 12.

Table 11. Basic setting of QP and CRF for Jockey test sequence with 4K resolution

| QP | PSNR(dB) | BR before H.265 (Kb/s) | BR after H.265 (Kb/s) | CR |
|---|---|---|---|---|
| 40 | 39.73 | 11943936 | 3789.32 | 3151.999831 |
| 44 | 37.958 | 11943936 | 2339.92 | 5104.420664 |
| 46 | 36.921 | 11943936 | 1863.77 | 6408.481733 |
| 48 | 35.795 | 11943936 | 1502.54 | 7949.163417 |
| CRF | PSNR(dB) | BR before H.265 (Kb/s) | BR after H.265 (Kb/s) | CR |
| 32 | 39.571 | 11943936 | 3766.03 | 3171.492527 |
| 36 | 37.625 | 11943936 | 2345.17 | 5092.993685 |
| 38 | 36.579 | 11943936 | 1915.37 | 6235.837462 |
| 40 | 35.508 | 11943936 | 1635.58 | 7302.569119 |
| 44 | 33.959 | 11943936 | 1384.07 | 8629.575094 |
| 46 | 33.867 | 11943936 | 1577.25 | 7572.633381 |
| 48 | 33.919 | 11943936 | 1928.96 | 6191.904446 |

Table 12. Optimal setting of parameters for Jockey test sequence with six resolutions

| Size | QP | GOP | REF | PSNR (dB) | BR before H.265 (Kb/s) | BR after H.265 (Kb/s) | CR |
|---|---|---|---|---|---|---|---|
| 4K | 46 | 100 | 3 | 36.921 | 11943936 | 1863.77 | 6408.481733 |
| 1080i/p | 42 | 100 | 3 | 36.277 | 2985984 | 1291.53 | 2311.97417 |
| 720p | 40 | 100 | 3 | 36.003 | 1327104 | 982.95 | 1350.123608 |
| 4CIF | 36 | 100 | 3 | 36.605 | 583925 | 975.9 | 598.3451173 |
| CIF | 32 | 100 | 3 | 36.4 | 145981 | 706.9 | 206.5087 |
| QCIF | 29 | 100 | 3 | 36.415 | 36495 | 447.03 | 81.63881619 |

## 4. CONCLUSION

In this study an adaptation of the UHD video streaming over the Internet when transmitting to the clients is the goal. The problem of limitation in bandwidth when the number of users are increasing on the network is solved by two steps; the first streaming an H265 for each format in parallel, while the second step is the incorporating of the controller to select the proper format. The experiments help us to find the optimal configuration for each format that achieves PSNR at 36dB. While the system works, the controller is continuously checking the status of the channel to select an appropriate video format to transmit over the available bandwidth. To send the video with one of formats less than UHD, at the clients either up sampling the received video into UHD or select an appropriate format to be convenient with application at the terminal devices. Also we test another scenario of the controller working, this scenario is more complicated where a lockup table of format configurations are prepared, when the controller checking the status of buffer then it send the instruction to encoder for applying the best configuration that was saved the quality of video with proper BR that suitable to available bandwidth, but disadvantage of this scenario is require fast processing and high properties of the devices because the rapidly variation of the channel status at time.

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