An Improved Video Coding Model for Future IMT Requirements

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Abstract. The annual need for digital wireless data continues to grow significantly, and the number of wireless devices is rapidly increasing, creating problems for current networks. Video data representing approximately 90% of the total data transmitted through networks constitute the most frequent data sent over these networks. To serve the greatest number of users, the volume of video data services needed by each user needs to be decreased. One of the goals of this paper is to improve existing mobile networks to help them meet the IMT-2022 specifications of high throughput and low latency. This paper is also devoted to developing a new video encoder model to provide the greatest number of users with video services by reducing the consumption of video data and cutting its volume. The proposed wireless scheme has the potential to support nearly 16% more consumers than LTE-ADV systems, while video encoding with the proposed wireless scheme can provide nearly 136% and 36% more users than LTE with H.265 and LTE-ADV with H.265, respectively.

Keywords: 4G · 5G · High-efficiency video coding · Ultra-high-definition · Filter bank multicarrier · International mobile telecommunications

1 Introduction

Wireless network connectivity has seen rapid technological advancement in the last 20 years. Using second-generation mobile technologies, a user could only make a phone call or deliver a short message service [1]. Furthermore, using fourth-generation technologies such as Long-Term Evolution (LTE), other practices such as high-speed Broadband connectivity, web gaming, video chatting, and video conferencing is now possible [2]. The Third-Generation Partnership Project consortium standardized LTE and its subsequent iterations [3].

Data traffic in mobile communications has risen significantly in recent years. Video providers account for a sizable portion of this data traffic [4]. In recent years, there has been an increased use of Internet-based applications, and more Internet-capable mobile terminals have been deployed throughout the world. The primary application driving the development of Long-Term Evolution Advanced (LTE-ADV) was to reach 1 Gbps peak data rates and to provide customers with a spectrum of telecommunications services [5].

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LTE-ADV uses multiple-component carrier aggregation [6–8] to boost the data rate to have a wide spectrum of bandwidth up to 100 MHz. The upcoming LTE update, called LTE-ADV -Rel.15, is still in its early stages, but it will allow DL data speeds of more than 3 Gbps and support emerging services like video calling, the Internet of Things, and smart cities. The LTE network roadmap must undergo several changes to satisfy International Mobile Telecommunications-2022 (IMT-2022) requirements, and the LTE specification will continue to incorporate new features [1].

The majority of data sent over these wireless networks is video data, indicating a pressing need to increase video transmission efficiency, as video data accounts for roughly 70%–90% of total data sent over networks. Advanced Video Coding (AVC/H.264) is the most common video coding format for wireless networks, and it's used to deliver a wide variety of application services to consumers. However, delivering high-definition content necessitates a wide bandwidth, which is impractical. By using sophisticated coding methods, high-efficiency video coding (HEVC/H.265) solves this challenge.

The Moving Picture Experts Group(MPEG) optimized it, and the bit rate is about half that of H.264 (at the same quality), making it a more realistic choice for providing HD, ultrahigh-definition (UHD), and 8K video services to consumers over wired and wireless networks. Currently, a network challenge exists due to the variety of video audiences and the speed of data speeds between devices, increasing in video file size to satisfy user requirements. Several researchers looked at various video coding output styles, based on two properties: subjective and objective consistency, as well as estimation approaches. When comparing AVC to HEVC, it was discovered that HEVC saved more bit rate while retaining the same efficiency.

In 2013, D. Grois and et al. [9] conducted a performance evaluation of H.265, H.264, and VP9 in terms of processing time. The results revealed that H.265 takes seven times longer to encode than VP9. The encoding times of VP9, on the other hand, are longer than those of AVC.

A. Jassal and al. [3] measured in 2016, using different buffer techniques, the value of each image frame given by video encoding and the approximate output under traffic conditions. The results showed a significant improvement over the baseline. In 2017, T. N. Huu and colleagues developed an efficient error concealment solution for real-world HEVC video transmissions that compensates for a missed entire frame and mitigates the error propagation issue [10]. The extension for H.265 was introduced by A. Ramanand and et al. in 2017 [11].

The findings revealed some of the most glaring unsolved issues in HEVC rate control. H. Azgin and et al. used FPGA to implement various angular prediction modes for HEVC in 2017 [12].

The proposed solution uses less energy than the standard solution. F. P. Pongsapan and et al. evaluated and examined HEVC over LTE in terms of PSNR with a set of videos in 2017 [13], using NS3 to test the performance. To determine the effect of a burst error, the authors used a variety of error rates. To reduce the bit rate, J. Huang and et al. combined two video coding standards, namely AVC and HEVC, into a single component in 2017 [14].

The results showed that using the high quantization value in H.265 and the low quantization value in H.264, the bit rate savings could be over 50%. To reduce complexity, In H.265 in 2019, Hai-Che Ting and colleagues suggested a modern convolutional neural network [15].

The results showed that the proposed method's complexity is reduced by up to 66% when compared to the H.265 standard, but bit rate increases and PSNR decreases. Jiang and colleagues reduced the complexity of H.265 for vehicular ad-hoc networks in 2019 [16].

The findings revealed that the proposed approach will minimize encoding time while rising delta bitrate as compared to H.265.

This paper aims to address the shortcomings of previous studies by proposing new video coding models and techniques that reduce complexity while maintaining quality. The rest of this paper is structured as follows. Section 2 introduces the proposed broadband system. Section 3 presents the proposed video coding. Section 4 illustrates the result of the proposed systems. Finally, the conclusion is presented in Sect. 5.

2 Proposed Broadband System

The existing cell phone cannot satisfy the demands of a broadband network, which involves high throughput, increased spectrum quality, and low latency.

As a consequence, 5G networks have been developed to address these needs; nevertheless, the expense of deploying and configuring 5G networks is greater than that of LTE-ADV networks, the challenge for communication engineers and operators working on 5G is to build 10 times the number of base stations required for LTE-ADV deployment.

Furthermore, 5G subscribers are projected to hit 1.9 billion by 2024, while LTE is expected to continue to be the leading broadband connectivity technology in terms of subscriptions for the far future, with approximately 5 billion subscriptions (From the Ericsson Versatility Report). As a result, improving mobile systems and increasing network capacity is a key topic for mobile system development and one of IMT-2020's goals.

The LTE interface protocol is based on a design similar to that of the 3.5G high-speed packet access protocol. The names of protocols and functions, on the other hand, are very similar; the differences are due to the multiple access techniques [17]. LTE is based on the packet data transmission method, which eliminates the need for old circuit switching systems. The user protocol stack is shown in Fig. 1.

The LTE system has bandwidth flexibility [19]. In the LTE system, The architecture achieves a higher data rate of approximately 1 Gbps. The proposed mobile framework is based on LTE-ADV, but with additional functionality. As shown in Fig. 2, the proposed system employs advanced technologies such as Modulation and Coding Scheme- proposed(MCS-Pro) and Filter Bank Multicarrier modulation- Offset Quadrature Amplitude Modulation (FBMC-OQAM).

Orthogonal frequency-division multiplexing (OFDM) is a multicarrier scheme that employs rectangular pulses during transmission and reception, resulting in a significant reduction in computational complexity due to the absence of the filter band and the use of a small number of FFT points. The CP also implies that the transmit pulse is

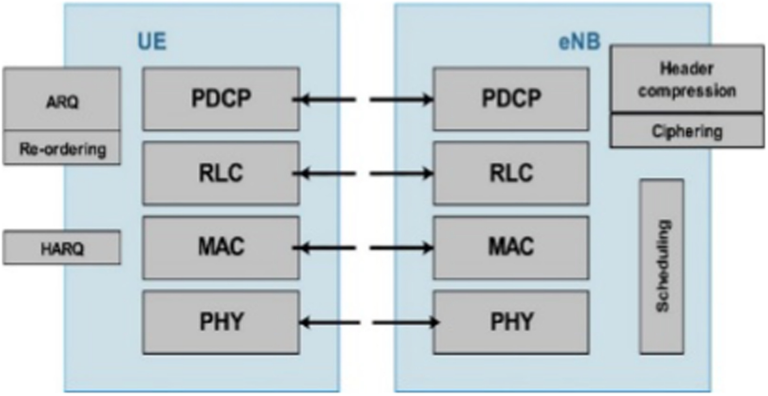

Fig. 1. Protocol stack on LTE [18].

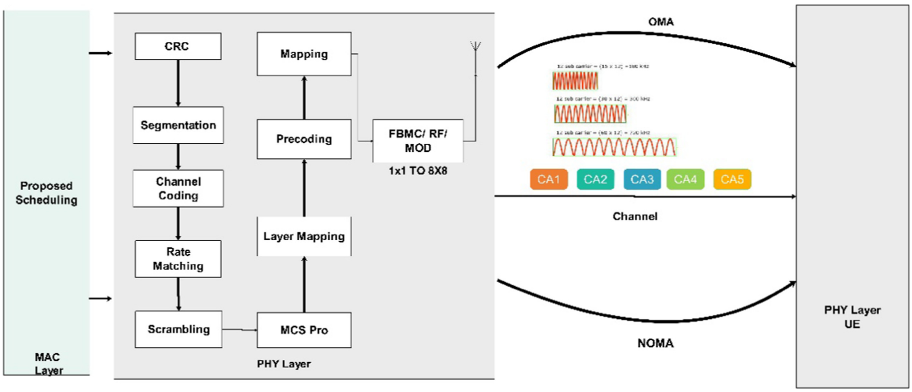

Fig. 2. Block diagram of the proposed system.

slightly longer than the received pulse; the duration of the rectangular pulse is equal to the duration of the real symbol plus the length of the CP. Furthermore, the rectangular pulse produces a lot of out-of-band (OOB) emissions and has low spectral efficiency. As shown in Fig. 3, FBMC is used to reduce OOB emissions in this study. Instead of the traditional MCS, which has a high coding efficiency, the proposed MCS is used. The proposed system is known as Pro-G, and its characteristics are listed in Table 1.

MCS recommended selecting the right modulation and coding quality to improve spectrum efficiency. MCS is selected as the best for each form of modulation, such as Quadrature Phase-Shift Keying (QPSK) and Quadrature Amplitude Modulation (16-QAM), where it determines three indices. However, the optimal pairs for 64-QAM and 256-QAM are three for 64-QAM and four for 256-QAM.

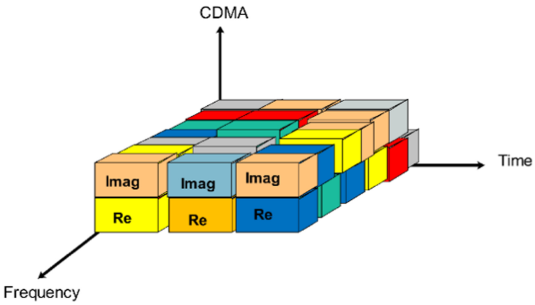

Fig. 3. Proposed FBMC

Table 1. Comparison of mobile system features

System	Proposed	LTE-ADV	LTE
Flexibility of bandwidth (MHZ)	1.25 to 60	1.25 to 20	1.25 to 20
Type of modulation	(MCS-Pro)	QPSK to 256QAM	QPSK to 64QAM
Waveform	FBMC	OFDM	OFDM
Size OF FFT (point)	128–3072	128–1024	128–1024
No. of carriers	72–3600	72–1200	72–1200
No. of RB	6–300	6–100	6–100
Carrier spacing frequency (KHZ)	15–60	15–30	15–30
No. of antenna	8 × 8	8 × 8	4 × 4

3 Proposed Video Coding for Future Mobile Systems

The standard video coding (H.265) is procedures in Fig. 4, which outline the configurations used to denote video coded data. H.265 sends blocks to the network abstraction layer [3].

Many changes have been introduced to H.265 including partition stability and further interpolation, a modern complicated and motion vector estimation, and support for several processes [3, 21, 22].

A block coding scheme is used in H.265 that involves coding tree units (CTU) and coding tree blocks, projection units, prediction blocks, transform units (TU), and transform blocks [23–26]. The proposed video coding for the proposed future video coding (PFVC) model is intended for use in today's and tomorrow's wireless mobile networks. The following are the key features of the proposed system: In a CTU, the Luma block can be up to 128 128 bytes in size. The number of directional intra modes in PFVC has been increased from 33 to 65, as in H.265. The raw video is first divided into CTUs. These units are subdivided into coding units (CUs) by a quadtree multitype layout, with a leaf coding unit describing an area that uses the same prediction mode.

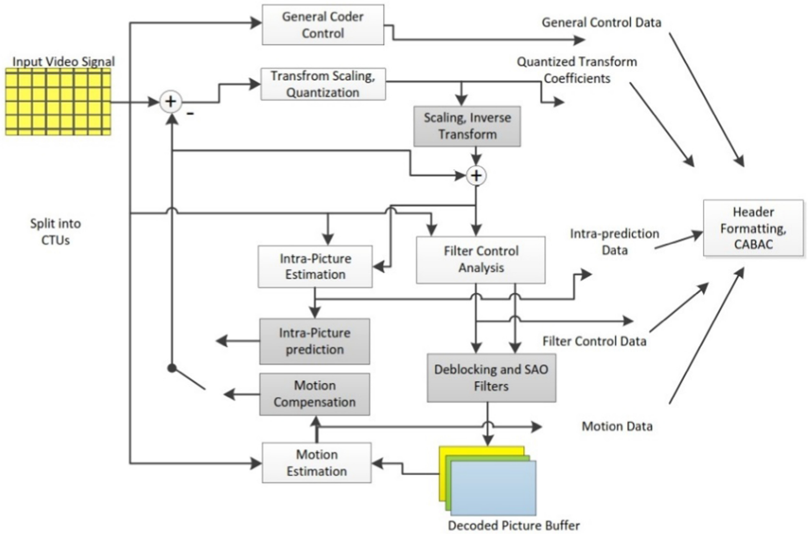

Fig. 4. The encoder of H.265 [20].

A quadtree is a nested multitype tree (MTT) with binary and ternary segmentation splits. In the coding tree structure, a CU can be square or rectangular. As a result, a quaternary tree (QT) structure is used to divide CTU into blocks. As shown in Fig. 5, the QT leaf nodes can then be further divided by a different type of construction (MTT structure). There are four types of splitting in an MTT system. The four forms of separating variance are horizontal binary, vertical binary, horizontal ternary, and vertical ternary.

A first flag (mtt split cu flag) is signaled in the MTT form to show if the node is partitioned further. As shown in Fig. 6, when a node is further partitioned, a second flag (mtt split cu vertical flag) indicates the splitting direction, and a third flag (mtt split cu binary flag) indicates whether the split is binary or ternary.

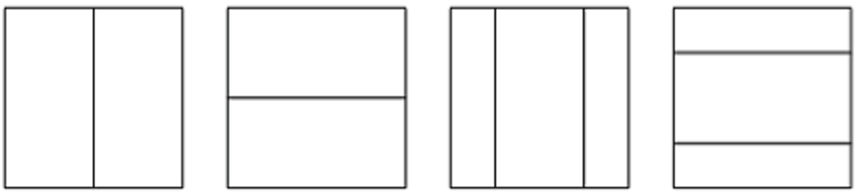

Fig. 5. Splitting types (vertical binary, horizontal binary, vertical ternary, and horizontal ternary) in the proposed model.

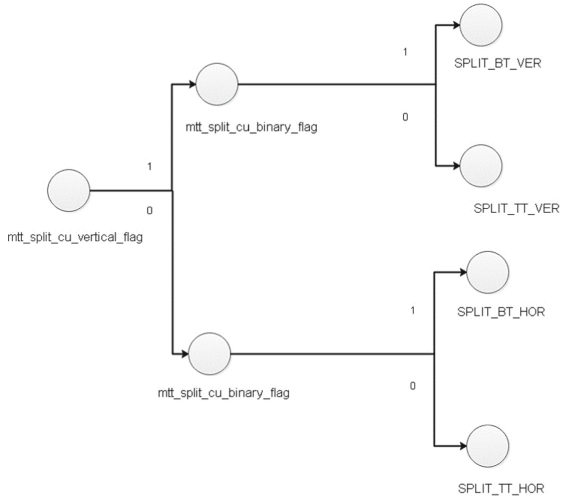

Fig. 6. Structure of proposed video coding model.

In PFVC, the number of directional intra modes was increased from 33 in H.265 to 65. As seen in Fig. 7, the current directional modes that are not present in H.265 are depicted by red dotted arrows, while the planar and DC modes stay unchanged in H.265. Furthermore, extra directional intra prediction modes are used in the chroma and luma blocks.

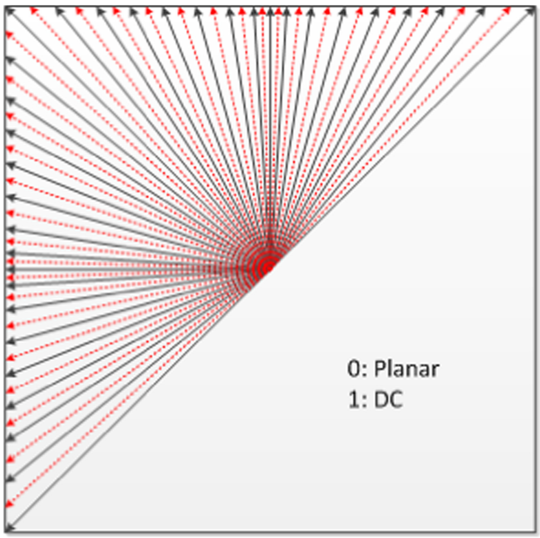

Fig. 7. Modes of Intra prediction in PFVC.

Six of the intramode coding methods are the most likely (MPM) mode used to minimize difficulty by taking account of two adjacent intra modes. Two adjacent blocks placed above and left are considered in nearby intra-mode. To initialize the default MPM list, six-MPM list generation begins as follows:

$$\text{Six Default MPM modes} \\ = \{A,\ Planar\,(0)\ or\ DC\,(1),\ VER\,(50),\ HOR\,(18),\ VER - 4\,(46), VER + 4\,(54)\} \tag{1}$$

HOR is horizontal where A is angular, and VER is horizontal. The pruning of two adjacent intra mode updates six MPM modes. Where 2 adjacent modes are the same and the adjacent mode is greater than the DC (1) mode, six MPM modes can include 3 default modes (A, Planar, and DC) and 3 derived modes, obtained by added pre-defined offset values and modular running. If two adjacent modes are incompatible, the first two MPM modes will be allocated to two adjacent modes and the other four MPM modes to default and neighbor modes.

4 Simulation and Results

Two wireless mobile networks were introduced in the first device to transmit video through it. Figure 8 shows a contrast of throughput performance for two mobile systems, Pro-G and LTE-ADV, with varying antenna counts. Pro-G has a throughput of approximately 965 Mbps with 8 * 8 MIMO, which is higher than the 829 Mbps offered by LTE-ADV. Pro-G delivers approximately 483 Mbps with 4 * 4 MIMO, while LTE-ADV provides approximately 415 Mbps.

The bit rate, PSNR, and encoding speed of PFVC and H.265 were compared to ascertain which video encoding scheme is most efficient. Various video resolutions were used and tested. Figure 9 shows the bit rate versus PSNR for different video encoding modes at 4CIF; the bit rate for PFVC performs better because it is lower than H.265 across a range of PSNR values. PFVC and H.265 offer 1074 and 1412 Kbps, respectively. When the PSNR is set to 40 dB, PFVC also provides a higher PSNR than H.265 of approximately 2 dB at the same bit rate.

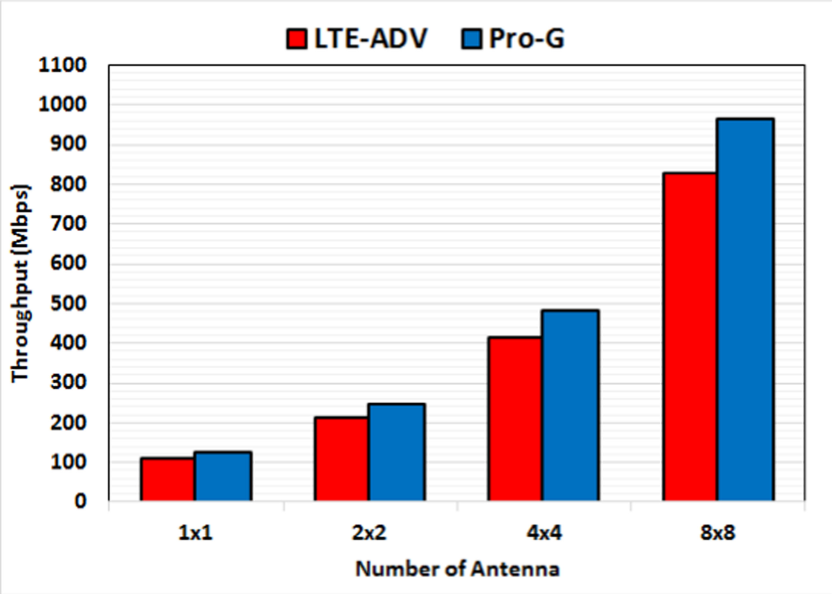

Fig. 8. Result of throughput for LTE-ADV and Pro-G systems

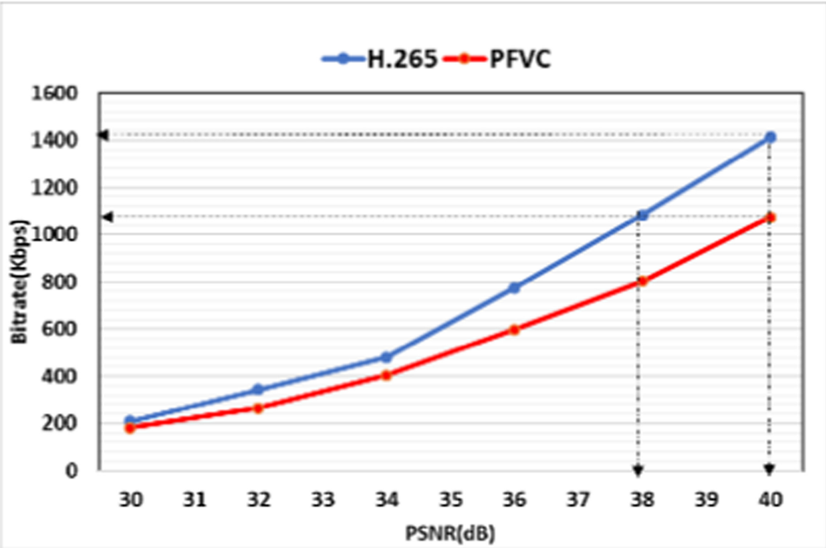

Fig. 9. Result of the bitrate between two video coding in 4CIF

Figure 10 represents the bit rate versus PSNR for various types of video encoding at 1080 HD, with PFVC outperforming H.265 because it has a lower bit rate over varying PSNR values. If the PSNR is set to 40 dB, PFVC and H.265 produce 1711 and 2181

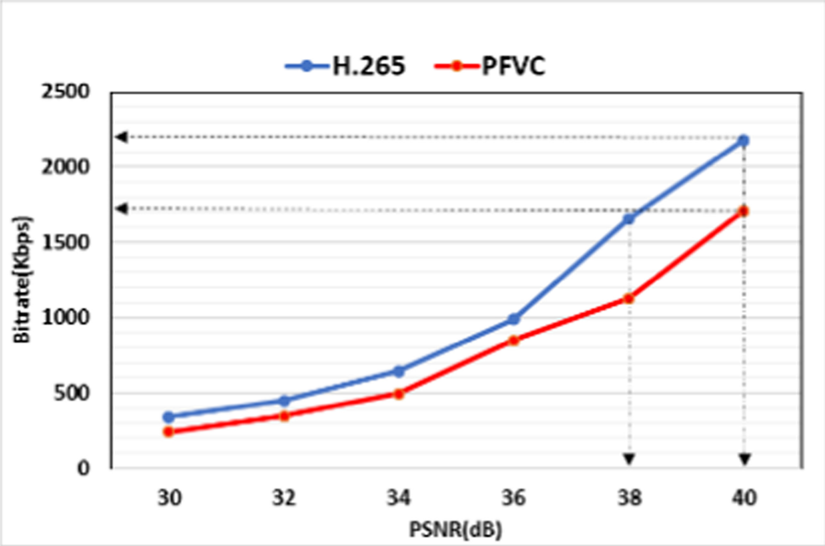

Fig. 10. Result of the bitrate between two video coding in HD

Kbps, respectively. PFVC also provides a higher PSNR than H.265 of approximately 2 dB at the same bit rate. Table 2 shows the compression output.

Table 2. Results of compression ratio (PSNR = 36 dB)

Type of resolution	PFVC	H.265
4CIF	814	628
720 HD	1919	1455
HD	3522	3020

In terms of HD video resolution, Fig. 11 indicates the number of users of different mobile devices utilizing Pro-G with H.265 and PFVC video-encoding models equating to approximately 976 and 1138 users, respectively, compared to 483 users for H.265 with LTE and 898 users for H.265 with LTE-ADV, respectively. The Pro-G and LTE-ADV system was compared to the results in the paper [27]. Table 3 displays the number of consumer results through three mobile networks.

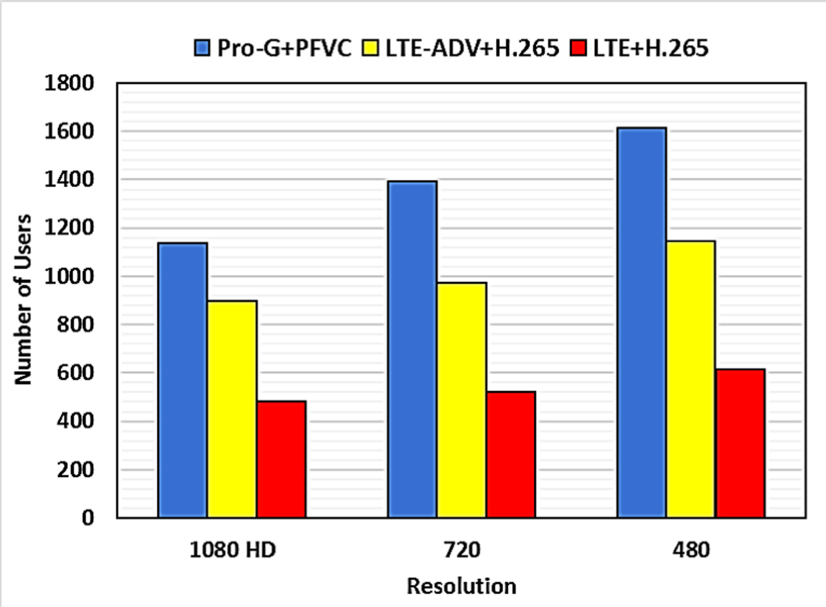

Fig. 11. Result of number of users for video coding time

Table 3. Number of video users for different video encoding

System	Resolution	PFVC	H.265
Pro-G	4CIF	1614	1246
	720	1395	1059
	1080	1138	976
LTE-ADV	4CIF	1486	1147
	720	1284	974
	1080	1048	898

5 Conclusion

In this article, two models were proposed. The first, the mobile wireless device channel technology, is proposed to increase spectral quality at low costs; the second, video coding, enables support to current and future video application requirements. The findings of the first model reveal that the suggested technique has a throughput of 16–16.5% greater than the LTE-ADV system. The findings of the video coding scheme reveal that PFVC has a lower bit rate than H.265 for various video resolutions. The results from the video coding scheme imply that PFVC has a lower bit rate than the H.265 for various video resolutions. The Pro-G with PFVC video encoding has approximately 136% more users than the LTE with H.265 and 36% more than the LTE-ADV with H.265.

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