Indonesian Journal of Electrical Engineering and Computer Science
Vol. 4, No. 2, November 2016, pp. 390 ~ 396
DOI: 10.11591/ijeecs.v4.i2.pp390-396

Video Transmission using Combined Scalability Video Coding over MIMO-OFDM Systems

Kalvein Rantelobo*[1], Hendro Lami[2], Wirawan[3]
[1, 2]Electrical Engineering Department, Nusa Cendana University, Jl. Adisucipto, Penfui, Kupang, NTT, Indonesia 90011
[3]Electrical Engineering Department, Institut Teknologi Sepuluh November (ITS), Kampus ITS, Sukolilo, Surabaya, Indonesia 60111
*Corresponding author, e-mail: rantelobo@ieee.org

Abstract

The needs of efficient bandwidth utilization and method to handle bandwidth fluctuation condition of wireless channel have become fundamental problems in video transmission. This research proposed Combined Scalable Video Coding (CSVC) that refers to Joint Scalable Video Model (JSVM), i.e. development of video coding H.264/AVC by exploiting scalable combination method using Medium Grain Scalability (MGS) on wireless channel of MIMO-OFDM (Multiple Input Multiple Output – Orthogonal Frequency Division Multiplexing) technology. The research shows that the scalable combination method can be implemented on the scenario for wireless transmission on multicast network. Experimental results show that the delivered quality is close to the alternative traditional simulcast delivery mechanism in MIMO-OFDM systems.

Keywords*: CSVC, video transmission, MGS, MIMO-OFDM, wireless channel*

1. Introduction

The advance development of ICT has brought us to a growing need of bandwidth. On the other side, the use of wireless technologies as increasing demand of mobile multimedia services make the important use of fluctuated bandwidth. The increasing use of wireless technology caused by increasing demand of mobile multimedia services makes fluctuated bandwidth an important issue to be considered. On the other side, video transmission quality as mobile multimedia service depends on wireless channel condition and bandwidth availability. Wireless communication has low reliability in fluctuated bandwidth that lead to significant degradation of signal quality

To overcome that video transmission problem, the use of MIMO-OFDM technology as wideband service in wireless channel has became a popular method that used by various researchers [1-3]. Meanwhile, advance video coding that commonly used in wideband video transmission is H.264 AVC (Advanced Video Coding). Unfortunately, performance of this video coding is still poor in handling the effect of channel and multipath fading.

One attractive method to solve problems in video transmission in wireless channel is by layering transmission method. In this method, bit streams are scaled into a number of scales of priority (layer), in the form of base-layer and enhancement layer, which is known as scalable video method. Scalable method also implemented in multicast network where receivers only receive video transmission as needed. Multicast method only suitable on multi user in wireless network compared to simulcast method which is conventional video transmission [4-6].

Research on the vision of SVC (Scalable video Coding) over broadband services has been reviewed in [4-5], while performances of SVC and its applications in [7-9]. SVC is known in 3 basics i.e. quality scalable (SNR scalable), temporal scalable, and spatial scalable. The combination of those basics, known as Combined Scalable Video Coding (CSVC) is carried out by combining the advantage of each scalable basic. For example, temporal scalable mode is used to transmit video that has bit rate priority and SNR scalable is used when quality is preferred.

Received August 13, 2016; Revised September 26, 2016; Accepted October 11, 2016

CSVC was proposed by various studies such as Hybrid Temporal-FGS (Fine Granular Scalability) by Schaar [10] and spatio-temporal by Domanski [11]. CSVC that adopted by JSVM is proposed by Schwarz [12]. Hillested has reported the implementation of SVC in broadband video transmission [13]. Jubran [14] and Mansour [15] have already used MGS on adaptive network but not implemented in broadband services. Yu Wang implemented SVC application on broadcasting system [16], and GAO Bingkun implemented SVC in broadband services [17]. Both [17] and [18] used separate SVC. Recent researches, as reported by Maudong Li [18-19] and Shengjie Zhao [20], are SVC that adopted in MIMO-OFDM system using SVC as general approach. In this paper, we used dominant CSVC to exploit SNR scalable using MGS (Medium Grain Scalability) method. Earlier JSVM used FGS (Fine Grain Scalability) and CGS (Coarse Grain Scalability) modes, but latter FGS was rejected for complexity and efficiency reasons, and then was replaced by MGS.

In this paper, we used dominant CSVC to exploit SNR scalable using MGS (Medium Grain Scalability) method. Earlier JSVM used FGS (Fine Grain Scalability) and CGS (Coarse Grain Scalability) modes, but latter FGS was rejected for complexity and efficiency reasons, and then was replaced by MGS.

To the best of our knowledge, CSVC scheme using MGS to enhance the quality of video streaming over MIMO-OFDM system has not well studied yet. This leads us to a new scheme of broadband wireless transmission in video packet delivery using MGS CSVC. In this work, we compare CSVC to non-SVC streaming framework based on MGS. This research is an extension of previous work [19-20], focuses more to MGS.

The following sections of this paper presented as below: section 2 present JSVM (Joint Scalable Video Model) standards, i.e. SVC (Scalable Video Coding) and CSVC method and MIMO-OFDM system over wireless channel in section 3 and 4 respectively. In section 5, we describe simulation in general, followed by results and discussion on section 6, conclusions and future work on section 7.

2. Scalable Video Coding (SVC)

SVC is part of standard development of H.264/MPEG-4 part 10 AVC (Advanced Video Coding), or H.264/AVC [7], [21-22]. The development processes took a long 20 years, start from H.262 and MPEG-2, followed by H.263+ and MPEG-4 [4]. Until now, SVC standard is still in amendment, and is a cooperative work of many parties to establish JSVM standard. Since January 2005, MPEG and VCEG join in JVT to carry into completion the amendment H.264/AVC as an official standard (Joint Video Team).

Scalability proposed for the first time to reduce packet (cell) loss in ATM networks (Ghanbari). It created 2 (two) groups of bit stream or layer, base-layer and enhancement-layer. Layer containing vital information is base-layer, while enhancement–layer loaded by residual information to improve image quality or video to be produced, as shown in Figure 1.

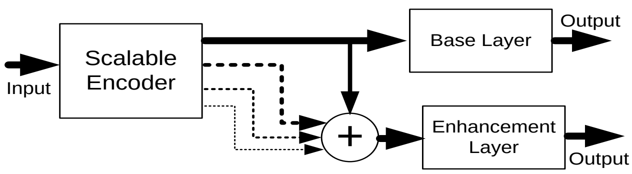

Figure 1. Scalability Coding System

Within data transmission process, in case of congestion in transmission channel, at least base-layer containing vital information still make it through. There are three types of scalability method as in Figure 1 SNR (Signal to Noise Ratio) Scalability, Spatial Scalability, and Temporal Scalability. Beyond that, there exists one type of scalability that combines the first three. The scheme of encoder and decoder systems of CSVC shows in Figure 2. This combined method is the main topic of this paper and will be discuss later in next section (section 3).

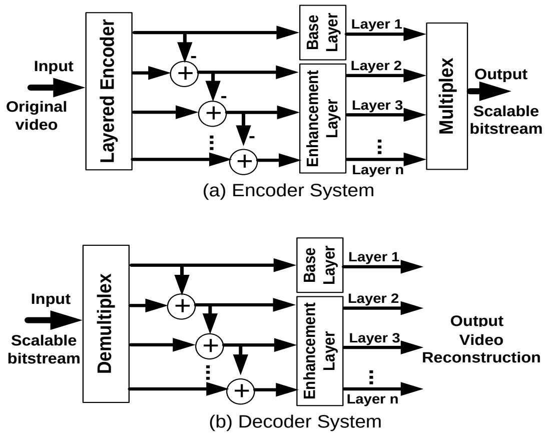

Figure 2. Encoder and Decoder of CSVC

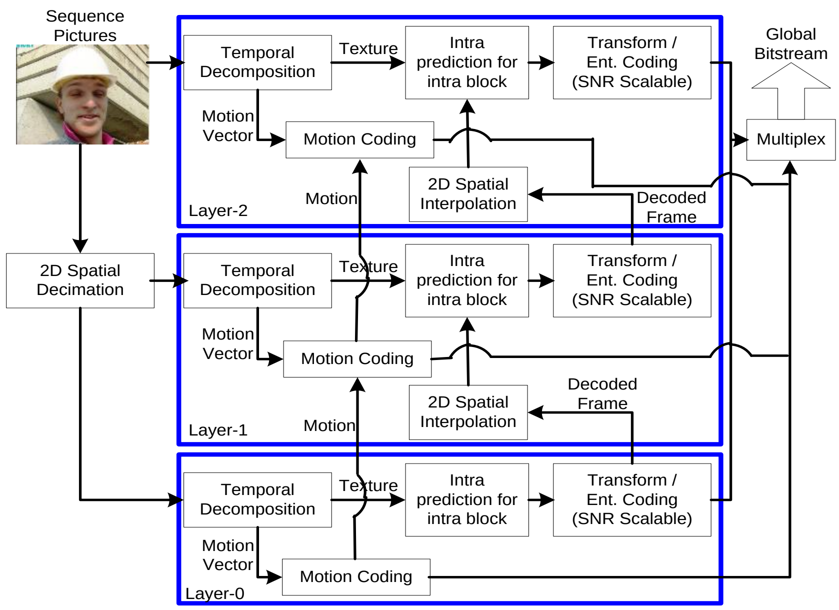

Figure 3. Structure of Encoder 3 Layer SVC

3. Combined Scalability Video Coding (CSVC)

The implementation of combined scalable is based on structure and efficiency of SVC coding. In case that the inter layer resolution changed, spatial scalable will be dominant. SNR scalable is dominant in changes of SNR, and temporal scalability dominant in changes of rate. Combination of those three is likely to be because of varying in sequences characteristics, fluctuated network condition and multi terminals [10], [12], [19-20].

This research utilizes three layers combined scalable, which includes 1 base layer and 2 enhancement layers, as shown in Figure 1. Block diagram of encoder-decoder with 3 layers combined scalable shown in Figure 3.

4. MIMO-OFDM Systems for Wireless Transmission

Former researches showed that OFDM technique considered had the capability to reduce constraint on wireless channel (Li, Chen, and Tan). Orthogonal Frequency Division Multiplexing (OFDM) is a transmission technique which divides the data into a number of independent frequency subchannels (ortogonal subcarriers) whose bandwidth is much less than the total data rate. In data transmission, multiple-input and multiple-output, or MIMO, is the use of multiple antennas at both the transmitter and receiver to improve communication performance. There are two types of MIMO that often become issues, Space Time Block Code (STBC) and Spatial Multiplexing (SM). STBC is used when performance improvement becomes important issue, despite of the spectral efficiency [1-2].

Space–time block coding is a technique used in wireless communications to transmit multiple copies of a data stream via indenpendent fading channel ortogonally, across a number of antennas, where at least one channel that doesn’t degrade from the worst fading. SM is used to improve performances that lead to a better spectral efficiency. Spatial multiplexing is a transmission technique in MIMO wireless communication to transmit independent and separately encoded data signals, so called streams, from each of the multiple transmit antennas. Therefore, the space dimension is reused, or multiplexed, more than one time.

Wireless environment especially in mobile multimedia communication services has become main issue in many researches. This research adopts some results from those previous works [12], [19], [23], [24] with main focus on impact on wireless channel from multipath fading and AWGN in combined scalable video transmission. Schematic illustration of this research is shown in Figure 4.

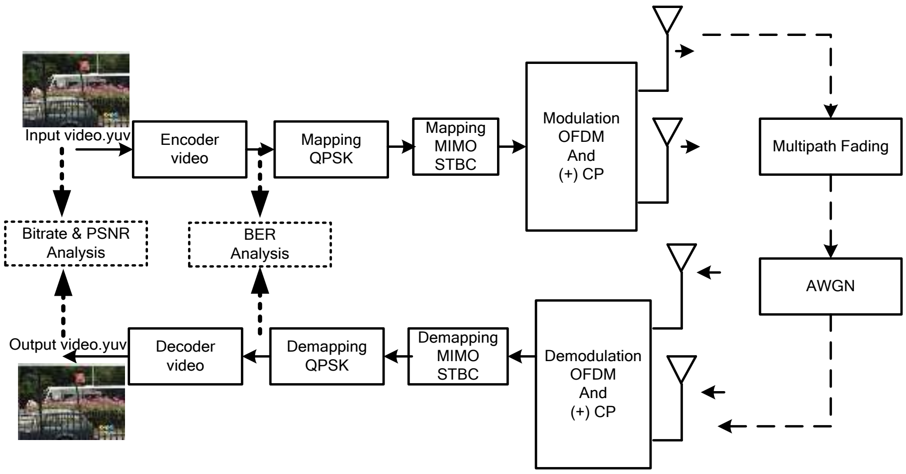

Figure 4. Schematic Illustration of this Research

The multipath fading (*H*) described by equation below

$$H = \sqrt{\frac{Hi^2 + iHs^2}{2}} \quad \text{(dB)} \tag{1}$$

Where

$$Hi = \frac{2}{N_0}\left(\sum_{n=1}^{N_0} \cos\beta_n \cos\omega_n t + \sqrt{2}\cos\alpha\cos\omega_n t\right), \tag{2}$$

$$Hs = \frac{2}{N_0 + 1}\left(\sum_{n=1}^{N_0} \sin\beta_n \cos\omega_n t + \sqrt{2}\sin\alpha\cos\omega_n t\right). \tag{3}$$

Hi and *Hs* (dB): Gaussian Random variable with mean 0 and variant σ^2; and N_0 : number of data [0, 1, 2, ... , *No*-1];

$$\omega_n = \omega_d\left(\cos\frac{2\pi n}{N_1}\right) \qquad n = 1,2,\ldots,N_0 \tag{4}$$

$$\beta_n = \frac{\pi n}{N_0}, \qquad \alpha = \frac{\pi}{4} \qquad \omega_d = 2\pi f_d \tag{5}$$

α and β_n: degree of fading phase (^{0}); and ω_d: Doppler shift (Hz).

5. Configuration of the Research

The configuration of the research implemented into simulation as in Figure 4 computes and analyzes BER, bit rate, and PSNR which utilize separate software. In order to examine video sequences, both input sequences and output sequences, we use MFC YUV viewer software and VLC media player. Channel transmission analysis utilizes Matlab (version 7) source. Source code of JSVM version 9.8 [25], runs on Microsoft Visual Studio.Net 2005.

The configuration of combined scalable that we used are: spatio-temporal scalable resolution and MGS scalability as scalable SNR ; 15 fps QCIF format picture on layer 1 (as base layer) ; 30 fps CIF on layer 2 (as enhancement layer 1) and 60 fps 4CIF on layer 3 (as enhancement layer 2). Combined-scalable runs over multicast network and non-combined scalable runs over simulcast networks. Table 1 lists general conditions and parameters set adopted in simulation of this research.

Table 1. Parameter Set Adopted in Simulation

Parameters	Description/Value
GOP size	16 frames
Spatial and Temporal Scalable	Spatio-temporal Scalable
SNR Scalability	MGS
Input Sequence	Bus.CIF, 100 frames, 30 fps
QP (Quantization Parameter)	22, 30, 38
Motion Search Range	±32
Number of Layer	4 layer (1 base, 3 enhancement)
CPU Test Platform	Proc. Intel Core 2 Quad 2.66 GHz
Mapping	QPSK
MIMO	STBC 2 x 2
Modulation	OFDM
N sub-carrier	48
N pilot	4
N carrier	64
Ncp	16
T OFDM symbol	4µs
fd	25 Hz
ts	100 µs
α	π/4

6. Results and Analysis

6.1. Pictures Quality Parameters

Peak Signal-to-Noise Ratio (PSNR) has been used to objectively measure the quality between an original sequence and a reconstructed sequence. This metric depend on the Mean Squared Error (MSE) given by:

$$MSE = \frac{1}{W \times H} \sum_{x=0}^{W-1} \sum_{y=0}^{H-1} \left| f(x,y) - g(x,y) \right|^2 \tag{6}$$

where *W* is number of pixel per row; *H* is number of row per frame; *f(x,y)* is pixel's luminance intensity in the original frame; and *g(x,y)* is pixel's luminance intensity in the reconstructed frame.

PSNR is defined as:

$$PSNR = 10 \log_{10} \frac{(2^n - 1)^2}{MSE} \tag{7}$$

where n is number of bits per pixel. Bit rate estimator is carried by:

$$B_r = \frac{N_b}{N_f} \times M_f \quad (8)$$

where B_r as Bit rate, N_b as total bit, N_f as number of frame, and M_f as mean frame rate. Input video sequence has been analyzed by quantization parameters (QP) 24, 32 and 40.

6.2. Result of Y-PSNR and Bit Error Rate (BER)

Results of this research using BUS sequence are shown in Figure 5 and Figure 6. Result analysis of PSNR versus bit rate in Figure 5 shows that the application of CSVC using the MGS yield a smaller bit rate on layer 0 and layer 1 (only 65 kbps to 600 kbps) when compared to the sequence of non-SVC (400 kbps to 2,500 kbps) on the corresponding PSNR Effect of BER (Bit Error Rate) in Figure 6 shows BUS sequences in MIMO-OFDM systems over transmission channel with AWGN and multipath fading, that have a larger BER when compared to non-SVC sequence (the average gap is about 5×10^{-2}).

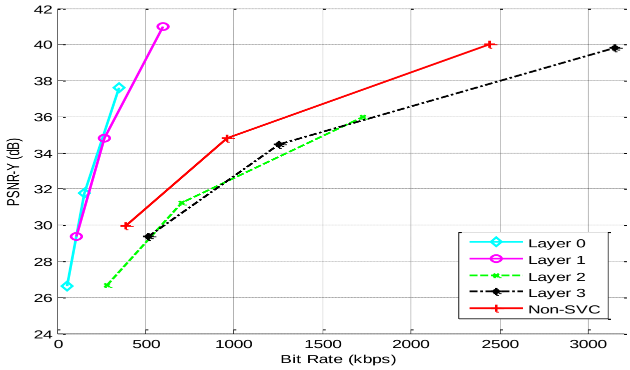

Figure 5. PSNR Versus Bit Rate from BUS Sequence

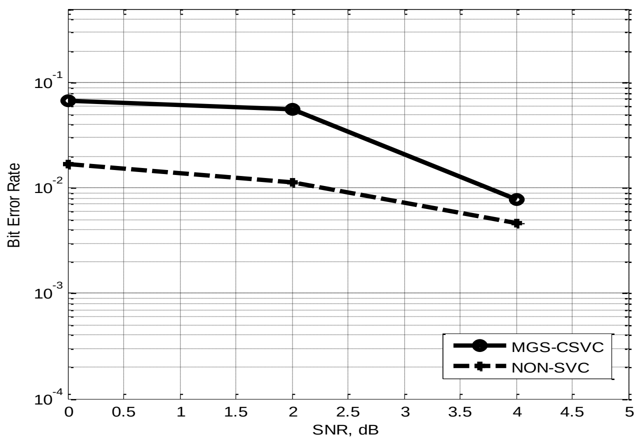

Figure 6. Error Rate from BUS Sequence Over MIMO-OFDM Systems

7. Conclusion

We presented video transmission using mode MGS based on the Combined SVC over wireless channel in MIMO-OFDM systems. We also investigated the impacts of the AWGN and multipath channel on performance of this system. The Application of MGS on CSVC increases the use of layers as compared to non-SVC. In general, our scheme can be implemented in video sequence on broadband multicast service.

The future work will focus on providing CSI (Channel State Information) using limited feedback method for our new novelties scheme for adaptive system for wireless transmission over video broadband services. We will continue our future result by using Network Simulator 3 (NS-3).

Acknowledgments

This study was supported by a Directorate General of Higher Education (DGHE) No. Grant 359/UN15.19.1/PL/2015, Ministry of National Education Republic of Indonesia.

References

[1]. Stuber GL, Barry JR, McLaughlin SW, Li Y, Ingram MA, Pratt TG. *Broadband MIMO-OFDM wireless communications.* Proc IEEE. 2004; 92: 271-294.
[2]. Bolcskei H. MIMO-OFDM wireless systems: basics, perspectives, and challenges. *IEEE Wirel Commun*. 2006; 13: 31–37.
[3]. Agiwal M, Roy A, Saxena N. Next Generation 5G Wireless Networks: A Comprehensive Survey. *IEEE Communications Surveys and Tutorials.* 2016; 99: pp.
[4]. Wu D, Hou YT, Zhang YQ. *Scalable video coding and transport over broadband wireless networks.* Proc IEEE. 2001; 89: 6–20.
[5]. Zhang Y-Q, Liu Y-J, Pickholtz RL. Layered image transmission over cellular radio channels. *IEEE Trans Veh Technol*. 1994; 43: 786–794.
[6]. Ghanbari M. Two-layer coding of video signals for VBR networks. *IEEE J Sel Areas Commun*. 1989; 7: 771–781.
[7]. Wiegand T, Sullivan GJ. *The H. 264/AVC video coding standard [Standards in a Nutshell].* Signal Process Mag IEEE. 2007; 24: 148–53.
[8]. Schwarz H, Marpe D, Wiegand T. Overview of the Scalable Video Coding Extension of the H.264/AVC Standard. *IEEE Trans Circuits Syst Video Technol*. 2007; 17: 1103–1120.
[9]. Wien M, Schwarz H, Oelbaum T. Performance Analysis of SVC. *IEEE Trans Circuits Syst Video Technol*. 2007; 17: 1194–1203.
[10]. Van der Schaar M, Radha H. A hybrid temporal-SNR fine-granular scalability for Internet video. *IEEE Trans Circuits Syst Video Technol*. 2001; 11: 318–331.
[11]. Domanski M, Luczak A, Mackowiak S. Spatio-temporal scalability for MPEG video coding. *IEEE Trans Circuits Syst Video Technol*. 2000; 10: 1088–1093.
[12]. Schwarz H, Marpe D, Schierl T, Wiegand T. *Combined scalability support for the scalable extension of H.264/AVC*. IEEE Int. Conf. Multimed. Expo 2005 ICME 2005. 2005: 4.
[13]. Hillestad OI, Perkis A, Genc V, Murphy S, Murphy J. *Adaptive H.264/MPEG-4 SVC video over IEEE 802.16 broadband wireless networks*. Pack. Video. 2007: 26–35.
[14]. Jubran M, Bansal M, Kondi L. Low-Delay Low-Complexity Bandwidth-Constrained Wireless Video Transmission Using SVC Over MIMO System. *IEEE Trans Multimed*. 2008; 10: 1698–707.
[15]. Mansour H, Fallah YP, Nasiopoulos P, Krishnamurthy V. Dynamic Resource Allocation for MGS H.264/AVC Video Transmission Over Link-Adaptive Networks. *IEEE Trans Multimed*. 2009; 11: 1478-1491.
[16]. Wang Y, Ostermann J, Zhang YQ. Digital video processing and communications. *IEEE Trans Circuits Syst Video Technol*. 2009; 19: 302–6.
[17]. Bingkun G, Chuanjun S, Zhaoyun S. *Application of Scalable Video Coding in Broadband Wireless Network Transmission*. 2010 Int. Conf. Electr. Control Eng. ICECE. 2010: 4649–4652.
[18]. Li M, Chen Z, Tan Y. Scalable resource allocation for SVC video streaming over multiuser MIMO-OFDM networks. *IEEE Trans Multimed.* 2013; 15(7): 1519–1531.
[19]. Rantelobo K, Wirawan W, Hendrantoro G, Affandi A. Combined Scalable Video Coding Method for Wireless Transmission. *TELKOMNIKA.* 2011; 9:295–302.
[20]. Rantelobo K, Nugraha KA, Wirawan, Hendrantoro G. *Combined scalability technique for video transmission over wireless channel with MIMO-OFDM systems*. 2009 Int. Conf. Instrum. Commun. Inf. Technol. Biomed. Eng. ICICI-BME. 2009; 1–5.
[21]. ITU-T Recommendation H.264. Advanced Video Coding for Generic Audiovisual Services. *Int Telecommuniations Union*. 2007:14496–506.
[22]. Schwarz H, Wien M. The scalable video coding extension of the H. 264/AVC standard. *IEEE Signal Process Mag*. 2008; 25:135.
[23]. Hua Li, Jing Bai, Shujian Liao, Juanping Wu. Simulation Models for MIMO Wireless Channels. *TELKOMNIKA*. 2013; 11: 158–66.
[24]. Stockhammer T, Hannuksela MM. H.264/AVC video for wireless transmission. *IEEE Wirel Commun*. 2005; 12: 6–13.
[25]. Joint Video Team. Joint scalable vide model JSVM-11 2007.