AHIVCS-004

Source: ETRI,

Title: Pseudo CR for Evaluation Result on Unequal Error Protection on Scalable Video

Document for: Agreement

Agenda Item:

This document proposes to include evaluation results on Unequal Error Protection on scalable video. The use case and solution for UEP existed in TR 26.903 and also in current IVCS TR. The evaluation result of UEP was also presented in S4-100039 in SA4 #57 and also in S4-100475 in SA4 #59 meetings. This P-CR incorporated comments and proposals raised in past meetings and requests to include final text into current IVCS TR.

CR-Form-v9

PSEUDO CHANGE REQUEST

⌘ TR 26.9de ⌘ rev - ⌘ Current version: 0.0.1 ⌘

Title:	⌘ Pseudo-CR for Evaluation Result on UEP
Source:	⌘ ETRI
Date:	⌘ 21/10/2010
Reason for change:	⌘ Text proposal for IVCS TR
Summary of change:	⌘ This P-CR includes text proposal for IVCS TR.
Other comments:	⌘

********** Start of 1st Change **********

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TS 26.346: "Multimedia Broadcast/Multicast Services (MBMS); Protocols and Codecs".

[2] 3GPP TS 26.234: "Transparent End-to-End Packet Switched Streaming Service (PSS); Protocols and Codecs".

[3] ITU-T Recommendation H.264 (03/09), "Advanced video coding for generic audiovisual services" | ISO/IEC 14496- 10:2009 Information technology—Coding of audiovisual objects— part 10: Advanced Video Coding".

[4] T. Schierl, Y. Sanchez de la Fuente, C. Hellge, and T. Wiegand: "Priority-based Transmission Scheduling for Delivery of Scalable Video Coding over Mobile Channels," 3rd European Symposium on Mobile Media Delivery (EUMOB), London, 2009.

[5] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[6] 3GPP S4-040729:"Adaptive Streaming Testbed using PSS Rel.6 Features".

[7] 3GPP TR 25.814 V7.1.0, “Technical Specification Group Radio Access Networks; Physical layer aspects for evolved Universal Terrestrial Radio Access (UTRA) (Release 7)”, Sep 2009

[8] 3GPP RAN1 Tdoc R1-061292, “MBMS throughput performance”, Siemens, RAN1 45th meeting, Shanghai, China, 8-12 May 2006

[9] 3GPP RAN1 Tdoc R1-061445, “E-MBMS Performance:Data Rates and Coverage”, Texas Instruments, RAN1 45th meeting, Shanghai, China, 8-12 May 2006

[10] 3GPP RAN1 Tdoc R1-062062, “10MHz E-UTRA Downlink Performance and Numerology”, Motorola, RAN1 46th meeting, Tallinn, Estonia, 28th August-1st September 2006

[11] 3GPP RAN1 Tdoc R1-063450, “Performance of MBMS with Partial SFN Operation”, QUALCOMM Europe, RAN1 47th meeting, Riga, Latvia, 6-10 November 2006

[12] 3GPP RAN1 Tdoc R1-070051, “Performance of MBMS Transmission Configurations”, Motorola, RAN1 47th-bis meeting, Sorrento, Italy, 15-19 Jan 2007

[13] 3GPP RAN1 Tdoc R1-0670819, “E-MBMS Performance Characterization”, QUALCOMM Europe, RAN1 48th meeting, St. Louis, USA, 12-16 February 2007

[14] 3GPP RAN1 Tdoc R1-071049, “Spectral Efficiency comparison of possible MBMS transmission schemes: Additional Results”, Ericsson, RAN1 48th meeting, St. Louis, USA, 12-16 February 2007

[15] M. Luby, T. Gasiba, T. Stockhammer, M. Watson, “Reliable multimedia download delivery in cellular broadcast networks,” Broadcasting, IEEE Transactions on, Vol. 53, Issue 1, Part 2, pp235-246, March 2007.

********** End of 1st Change **********

********** Start of 2nd Change **********

6 Evaluation of Solutions

6.1 2D Use Cases

6.1.2 Solution Integration Approaches

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6.1.3 Performance Evaluation

6.1.3.1 Unequal Error Protection in MBMS

In this section, evaluation result of SVC UEP (Unequal Error Protection) method against single layer H.264/AVC is presented. The related use case is presented in section 5.1.3, and a solution of UEP is described in section 6.1.2.2.

In this evaluation, MBSFN channel of 9Mbps throughput in 7 sectors layout is applied commonly to the video streams. Only the ratio of application layer FEC packets is manipulated to test the UEP performance. In this experiment, Raptor code as in TS26.346 Multimedia Broadcast/Multicast Service (MBMS) is used as an FEC method.

In order for fair comparison, the PSNR of H.264/AVC encoded source file and SVC two layer files are produced to be identical (=35.4dB). Due to slightly high coding overhead of SVC, the file size of SVC becomes 7% ~ 15% larger than H.264/AVC file. Foreman QCIF and CIF sequences are encoded with the JSVM 13.1. The bitrate of H.264/AVC stream is 398kbps, while those of SVC base layer and enhancement layer are 48kbps and 383kbps, respectively if PSNR is set to be identical. Bitrate of SVC in total is 431kbps, which is 8% more than that of H.264/AVC.

Since equal amount of radio resources should be allocated for transmitting the AVC and SVC streams, the numbers of FEC redundancy packets are adjusted to make the total amount of physical blocks of the two streams identical. Therefore, FEC stream of 126kbps is added to H.264/AVC stream, and FEC streams of 90kbps is added to SVC stream, as a result, total bitrate of both codecs become 524 kbps (= video+parity). Note that this gives 8% more favourable protections to H.264/AVC.

The code rate of H.264/AVC single layer including the FEC overhead is 0.72. The protection period of FEC is 4 GoP length (=2 seconds), of which the size of GoP is 16 in 30Hz frame rate.

SVC two layer file is generated in 1:8 ratio of base : enhancement. The code rate of base layer including the FEC overhead is 0.41, and 0.87 in enhancement layer. Hence the base layer protection is enforced while sacrificing the enhancement protection.

Detail of the sample file specification is further described below;

Codec	AVC	SVC		
		Enhance layer	Base layer	(Altogether)
Sequence	Foreman	Foreman		
Resolution / Frame rate	CIF / 30Hz	CIF / 30Hz	QCIF / 15Hz	
PSNR [dB]	35.4	35.4	27.5	35.4
Bit-rate [kbit/s]	397.7	383.0	47.9	430.9
File Size (bytes)	848,112	816,768	101,816	918,584
# of Packets ***(=k)*** (512 byte/packet ± α)	208	200	25	225
Parity packets ***(=n-k)*** (Raptor FEC)	82	29	36	47
Sum of Packets ***(=n)***	290 (=208+82)	229 (=200+29)	61 (=25+36)	290 (=229+61)
FEC Code Rate ***(=k/n)***	0.72	0.87	0.41	***n/a***

% Common Factors

- GOP size : 16
- FEC Protection Period : 1 GoP (=0.5 seconds)
- MBSFN Layout : 7 sector layout (ISD=500m)
- Physical Channel : MCS-3, 64 QAM, 1/2 rate (=9Mbps throughput)

The MBMS channel loss model described in Annex A is applied in this experiment. 9 Mbps throughput channel (i.e. 64QAM modulation and 1/2 coding rate) is selected to apply the block loss rate equally to the AVC and SVC streams. In consequence, PSNR performance, as described in following equation, is measured at each coverage point.

In the example, the number of H.264/AVC video packets is 208 ***(=k),*** and the number of parity packets for it is 82. Therefore the coding ratio ***(n, k) = (290, 208),*** where ***n*** is total sum of the packets.

According to [15], the failure probability of Raptor is calculated as following Equation (1).

$$P_f(m,k) = \begin{cases} 1 & m < k \\ 0.85 \times 0.567^{m-k} & m \geq k \end{cases} \quad (1)$$

서식 9

In the Equation (1), ***m*** is the number of packets including video and parity received correctly through the radio channel, and ***k*** is the number of original video packets before transmission. Note that ***k*** doesn't include the number of parity packets. It is an important characteristic of Raptor code that failure probability is subject to ***m-k*** regardless of ***k***.

Assuming that we are measuring PSNR, GOP by GOP, the PSNR of AVC single layer (i.e. $PSNR_{single}$(dB)) is calculated as following Equation (2).

$$PSNR_{single}(\mathrm{dB}) = \sum_{m=0}^{n} P_{sm}\left(PSNR_0 P_f(m,k) + PSNR_s\left(1 - P_f(m,k)\right)\right) \quad (2)$$

서식 9

In the above Equation (2), it is assumed that a damaged GOP is replaced by the last decoded frame of previous GOP, hence the $PSNR_0$ denotes the PSNR of the freezed GOP. P_{sm} is the probability that ***m*** packets are received successfully among ***n*** transmitted packets. This probability is typically calculated using Poison function. $PSNR_s$ is the original undamaged PSNR of the GOP.

The PSNR of SVC (i.e. $PSNR_{scalable}$(dB)) is calculated as Equation (3) when it consists of only 2 layers.

서식 9

$$PSNR_{scalable}(dB) = \sum_{i=0}^{n_b}\sum_{j=0}^{n_e} P_{bi}P_{ej}(PSNR_0 P_f(i,k_b) + PSNR_b\left(1 - P_f(i,k_b)\right)P_f(j,k_e) + PSNR_e(1 - P_f(i,k_b))(1 - P(j,k_e))) \quad (3)$$

where, n_b : number of original base layer packets + parity packets for base layer

k_b : number of base layer packets

n_e : number of original enhancement layer packets + parity packets for enhancement layer

k_e : number of enhancement layer packets

P_{bi} : probability that i packets are received successfully among n_b transmitted packets

P_{ej} : probability that j packets are received successfully among n_e transmitted packets

$PSNR_0$: PSNR of freezed GOP, when the whole GOP is damaged

$PSNR_b$: PSNR of original undamaged base layer GOP

$PSNR_e$: PSNR of original undamaged enhancement layer GOP

In Equation (3), note that $P_f(i, k_b)$ is the failure probabilities of Raptor decoding given that i packets are received out of n_b transmitted packets. Similarly, $P_f(j, k_e)$ is the failure probabilities of Raptor decoding given that j packets are received out of n_e transmitted packets.

The PSNR equation (2) and (3) are correct within 4% error margin compared to real sequence test.

Figure 1x shows the evaluation result of PSNR performance at each coverage point. Note that the coverage in this context is the ratio of area that can guarantee the level of PSNR in the 7 sector MBSFN area.

In the Figure 1x, it is observed that the source file PSNR (=35.4dB) of both the H.264/AVC stream and the SVC stream are maintained up to 45% area. However the quality of SVC (solid red curve) begins degrading down to 27.5 dB which is the PSNR of original base layer. This means the enhancement data of weak protection losses earlier, however the base layer of strong protection survives within 65% coverage in the 7 sector MBSFN area.

H.264/AVC (dotted line) maintains quality until 55% area, however the quality degrades quickly thereafter. Compared to H.264/AVC, SVC shows characteristics of graceful quality degradation, and the quality outperforms H.264 in larger coverage.

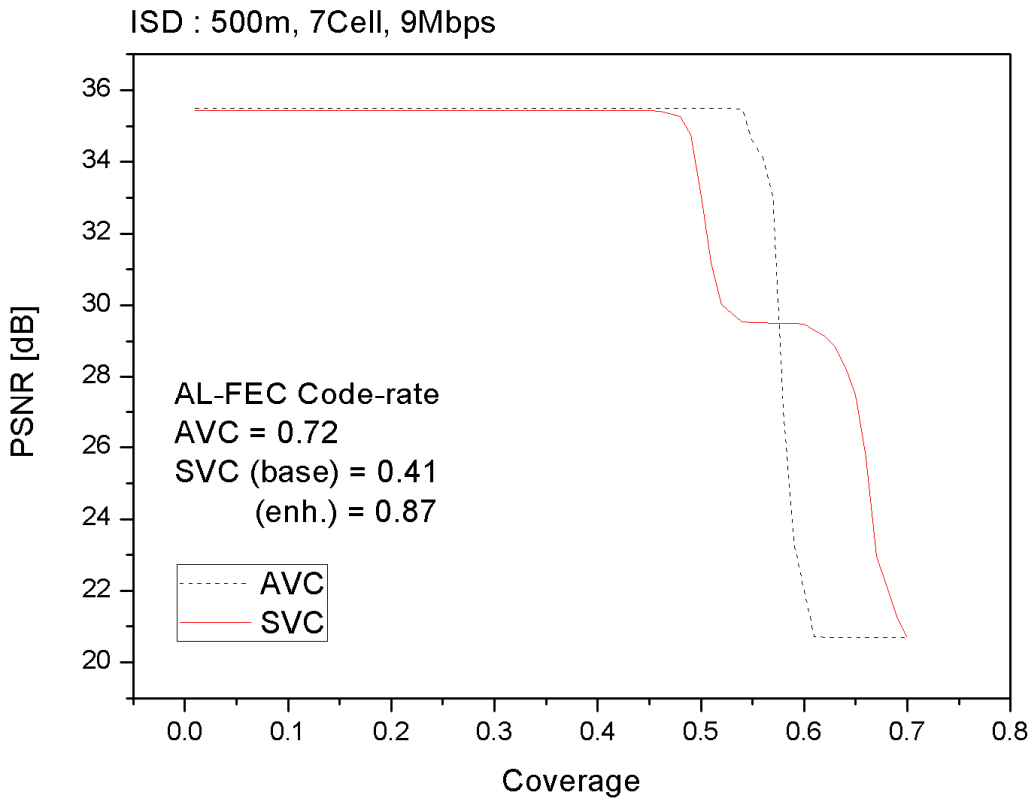

Figure 1x: Comparison of PSNR Curves of H.264/AVC and SVC

Figure 2x~3x shows coverage v.s. PSNR curves in 19 sector layout and 37 sector layout. Although the range of performance variation may slightly be reduced, the effect of graceful quality degradation of SVC is observed identical in different sector layouts.

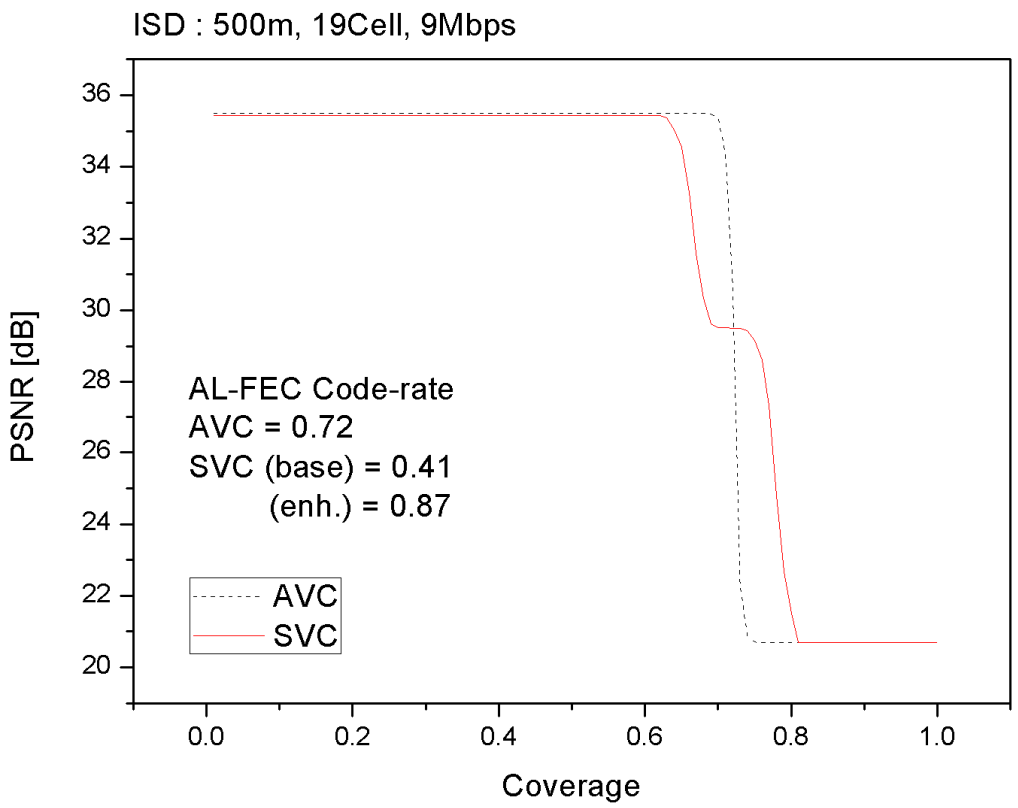

Figure 2x: PSNR Curves in 19 MBSFN Sector Layout

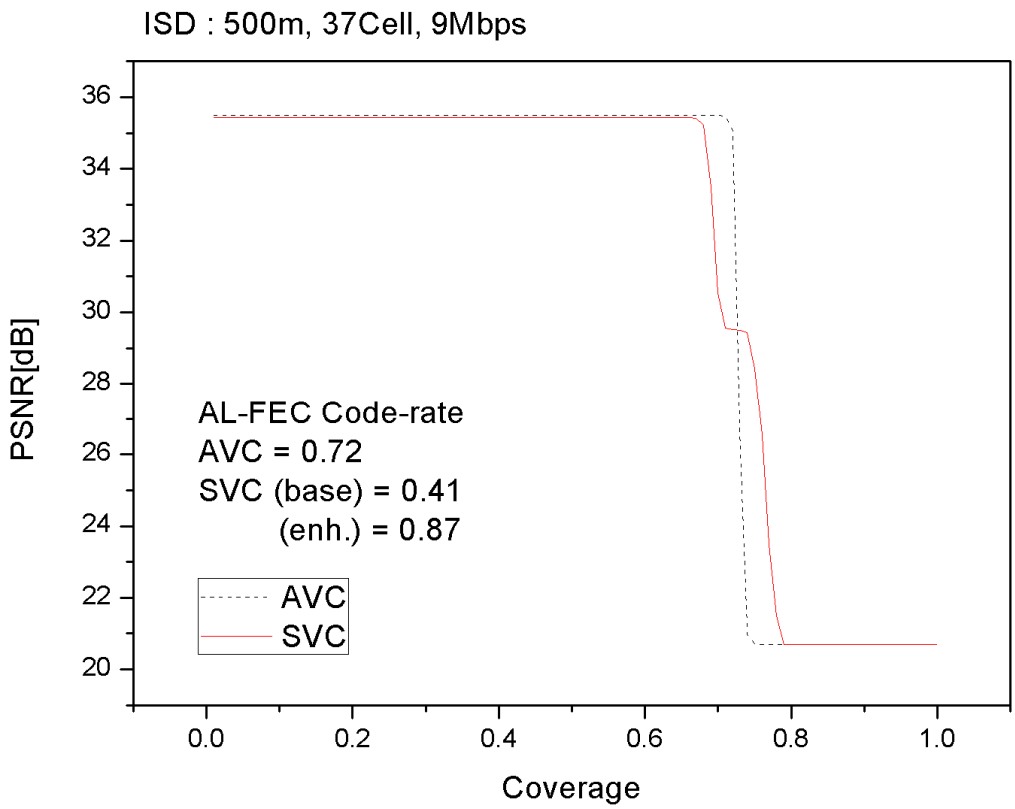

Figure 3x: PSNR Curves in 37 MBSFN Sector Layout

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