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Subject: **Results of Core Experiment I.4 - Scalable Side Information**

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Abstract

This document discusses results obtained within the framework of Core Experiment I.4 "Scalable Side Information". The purpose of this experiment was to investigate the possibility of reducing side information on the lowest layer scale_2 in scalable coding schemes. Experiments were performed on four coding architectures in comparison to a single layer TM2 implementation. Results show that a target bit rate of 750 kbps at the lowest layer is realisable using scalable side information and appropriate scaling of quantisation between the layers.

A. Core Experiment I.4 for Scalable Side Information

Scalable coding has been identified as a useful technique for providing the possibility to decode video at different spatial resolutions and qualities from a single bitstream. Frequency domain scalability has been introduced within the MPEG forum suitable for a variety of applications. The basic scalability approach as proposed by Gonzales and Viscito [1] already provides a basic syntax suitable for scalable coding. However, it has been recognised that for some applications, for example scalable coding for multichannel transmission with lower layers bit rates below 1 Mbps, the basic scalability syntax may not be suitable. This is due to the transmission of macroblock side information completely within the lowest scale_2 layer.

To this end scaling of macroblock side information has been proposed with the aim of distributing side information more evenly between the layers [2]. This has been summarised in Core Experiment I.4 which aims for multichannel scalability, each layer at fixed bandwith [3].

This contribution describes results obtained within the framework of Core Experiment I.4 for encoding video at different resolution scales (QSIF, SIF and R.601) targeted for bit rate distribution 0.75, 1.5 and 4 Mbps between the layers.

B. Coding Architectures

The experiments for different side information implementations were all performed using a scalability pyramid approach [1]. To avoid drift problems between the lower scales encoder and decoder images a three encoding loop scheme was implemented as depicted in Figure 1. In this scheme DCT domain frequency splitting, T8, is performed prior to coding to provide appropriate input signals for the lower scales. DCT and inverse DCT (T8 and t8) are incorporated into the individual encoding loops. Upward prediction for all layers is performed in the DCT frequency domain.

The following schemes were implemented to compare the impact of different strategies for side information coding:

I. SL: Single layer TM2 coding scheme. This scheme was implemented as a reference to compare the performance of the scalable coding schemes.

II. SCAL: Basic scalability syntax according to [1]. In this implementation side information is transmitted only in the base scale_2 layer. The slave layers scale_4 and scale_8 only contain DCT coefficients.

III. SCAL+Q: Scalability approach with scaled quantisation: The purpose of this implementation is to reduce the number of coded DCT coefficients in the scale_2 and scale_4 layers by scaling of quantisation within these layers with respect to scale_8. Scale_2 coefficients were quantised with a quantisation stepsize, quantiser_scale_2 = 4*quantizer_scale_8. quantiser_scale_4 = 2*quantizer_scale_8.

IV. SSI: Scalable side information implementation according to Core Experiment I.4: Macroblock addresses, macroblock types, coded block pattern and quantiser_scales can be transmitted for each coded block in each layer to achieve independent layered coding. Slave layer macroblocks at the same address in different layers are no longer slaved to the macroblocks in the base layer. In contrast to SCAL and SCAL+Q motion vectors are transmitted as incremental motion vectors. Additional motion estimation is performed on scale_4 layer. The implementation of this scheme follows strictly the proposal outlined for the Core Experiment. We refer to the definition of Core Experiment I.4 in [3] for further implementation details.

V. SSI+Q: SSI and additional scaling of quantiser stepsizes as in III.

C. Experimental Set-Up:

To meet the target bit rate in the individual layers, slice granularity multilayer rate control was implemented [3]. The experiments were performed using the scalability architecture in Figure 1 and the side information schemes described above. All layers were coded with full frame rate. Total overall bit rate for all schemes under investigation was 4 Mbps. Target bit rates for the three layers are depicted in Table 1.

Source material used for comparison were the first 94 frames of the sequences Calendar, Ballet and Fountain, all in 4:2:0 format.

For comparison purposes Peak Signal-to-Noise Ratio (PSNR), actual bit rate generated by the coder as well as the amount of side information coded in the individual layers were summarised. The side information bit rate contained all bits except coded DCT coefficients and end of block data. Actual bit rate generated in the individual layers was compared with the target bit rate according to Table 1 to classify whether the target bit rate was met. Roughly +/- 50 kbps tolerance around the target bit rate for scale_2 and scale_4 and +/100 kbps for scale_8 were allowed for the individual layers.

D. Results and Discussion:

The results of the experiments are summarised in Tables 2-4 for the various coder implementations and test sequences. The results indicate that only an implementation with scaled side information plus additional quantiser scaling, SSI+Q was able to meet the target bit rate of 750 kbps for the lower layers consistently in all test sequences. For less critical test sequences like Fountain and Ballet the basic scalable side information approach, SSI performed well. The basic scalable approach SCAL however was not able to meet the target bit rate in all the sequences used in our experiments.

The basic scalability approach SCAL had all macroblock side information contained in the scale_2 layer. This alone already accounted for more or nearly the target bit rate of the scale_2 layer. As a result the scale_2 bit rate exceeded the target bit rate. An additional scaling of the quantiser stepsizes according to SCAL+Q did improve the performance but still the target bit rate could not be met.

In contrast, the SSI scalable side information implementation was successful in meeting the target bit rate for the less critical sequences Ballet and Fountain, shown in Tables 2 and 3, with PSNR values 0.2 - 0.4 dB below the equivalent single layer SL scheme. However, as shown in Table 4, for test sequence Calendar the SSI approach alone was not able to meet the target bitrate.

This was only possible with additional scaling of quantiser stepsizes on scale_2 and scale_4 according to approach SSI+Q. It should be noted however, that this result was obtained at the expense of loss of quality on all layers. A PSNR loss well above 1 dB compared to the single layer in Table 4 was observed with the SSI+Q implementation and sequence Calendar.

Figures 2 and 3 depict PSNR profiles for SSI and SSI+Q approaches using test sequence Fountain.

E. Conclusion:

Our results have confirmed, that the basic scalability approach as proposed by Gonzales and Viscito does not give satisfactory performance at lower layers for low bit rates around 750 kbps. Results indicate however, that an extension of this approach using scalable side information as outlined in TM2 Core Experiment I.4 plus the implementation of additional quantiser stepsize scaling can resolve this problem. We therefore propose to adapt the scalable side information syntax as an addition to the basic scalability syntax. More experiments need to be performed to optimise quantiser scaling between layers as well as incremental macroblock vlc tables.

References

[1] C. Gonzales and E. Viscito, "A Proposal for MPEG-1 Coding with Scalable Extensions", ISO-IEC/JTC1,/SC2/WG11, MPEG 91/212Nov. 1991,.

[2] T. Sikora, T.K. Tan and A. Johnson, "Proposal for Frequency Scalability Experiments", ISO-IEC/JTC1,/SC2/WG11, MPEG 92/384, July 1992.

[3] MPEG 2 Test Model 2, ISO-IEC/JTC1,/SC2/WG11, MPEG 92/384, July 1992.

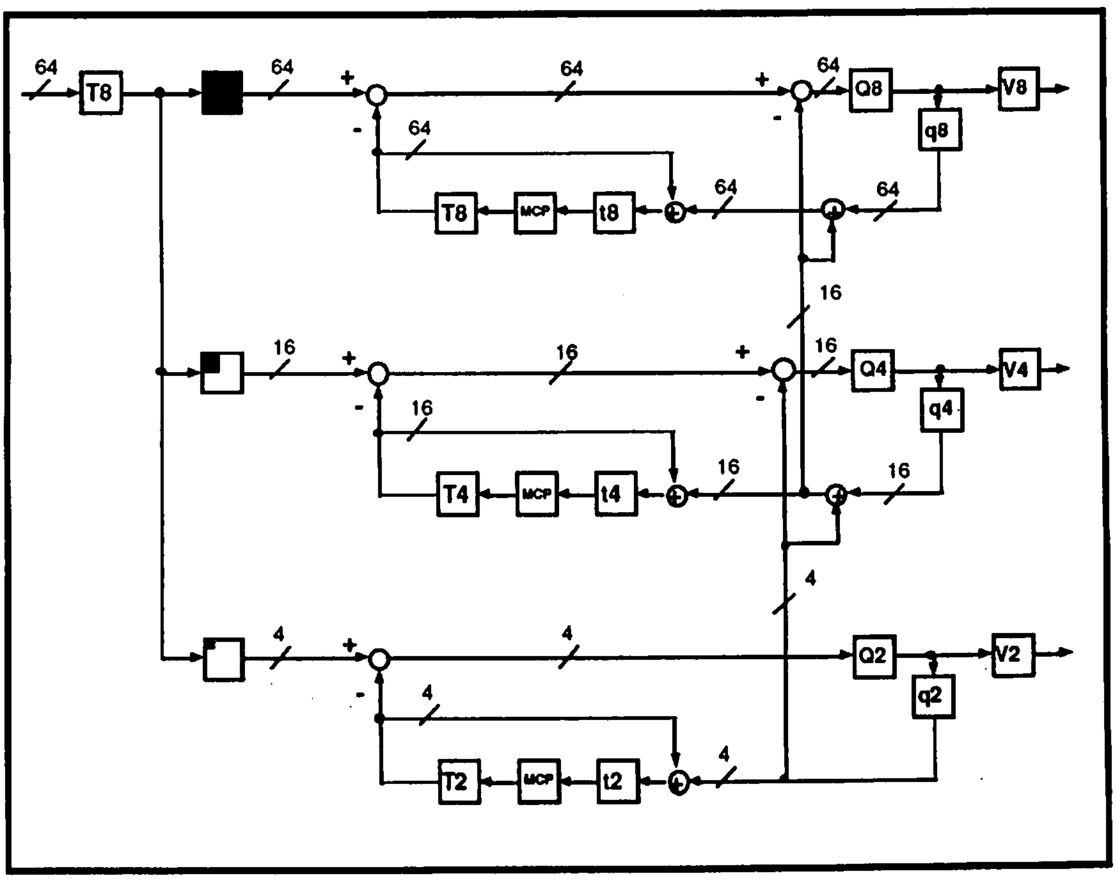

Figure 1: Three layer scalability coding scheme

Resolution	Layer	Target bit rate [kbps]
R.601	scale_8	2500
CIF	scale_4	750
QCIF	scale_2	750

Table 1: Target bit rates for the individual layers

Ballet

I. SL Single Layer

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	41.42	3914	766	yes

II. SCAL Basic Scalable Coder

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	42.45	2493	29	yes
Scale_4	41.42	771	45	yes
Scale_2	38.40	1022	691	no

III. SCAL+Q Basic Scalable Coder + Scaled Quantiser

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	42.42	2488	29	yes
Scale_4	41.17	763	45	yes
Scale_2	33.17	945	693	no

IV. SSI Coder with Scalable Side Info

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	41.29	2465	514	yes
Scale_4	40.32	743	334	yes
Scale_2	41.16	766	399	yes

V. SSI+Q Coder with Scalable Side Info + Scaled Quantiser

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	40.61	2456	508	yes
Scale_4	39.68	737	334	yes
Scale_2	40.63	758	389	yes

Table 2: Results for sequence Ballet

Fountain

I. SL Single Layer

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	34.61	3912	605	yes

II. SCAL Basic Scalable Coder

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	35.13	2473	29	yes
Scale_4	33.54	776	45	yes
Scale_2	36.45	1024	579	no

III. SCAL+Q Basic Scalable Coder + Scaled Quantiser

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	34.85	2466	29	yes
Scale_4	31.29	742	45	yes
Scale_2	35.26	809	581	no

IV. SSI Coder with Scalable Side Info

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	34.12	2428	271	yes
Scale_4	32.49	725	255	yes
Scale_2	37.11	722	310	yes

V. SSI+Q Coder with Scalable Side Info + Scaled Quantiser

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	32.85	2444	270	yes
Scale_4	31.29	734	258	yes
Scale_2	35.26	736	339	yes

Table 3: Results for sequence Fountain

Calendar

I. SL Single Layer

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	28.56	3989	788	yes

II. SCAL Basic Scalable Coder

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	28.11	2707	29	no
Scale_4	28.63	1158	45	no
Scale_2	32.86	1410	745	no

III. SCAL+Q Basic Scalable Coder + Scaled Quantiser

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	28.03	2574	29	yes
Scale_4	27.06	795	45	yes
Scale_2	25.77	1004	734	no

IV. SSI Coder with Scalable Side Info

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	27.71	2617	533	no
Scale_4	27.87	1196	523	no
Scale_2	32.99	1107	526	no

V. SSI+Q Coder with Scalable Side Info + Scaled Quantiser

Layer	PSNR [dB]	Bit rate [kbps]	Side Info [kbps]	Target bit rate met
Scale_8	27.15	2498	579	yes
Scale_4	25.26	752	495	yes
Scale_2	27.95	752	494	yes

Table 4: Results for sequence Calendar

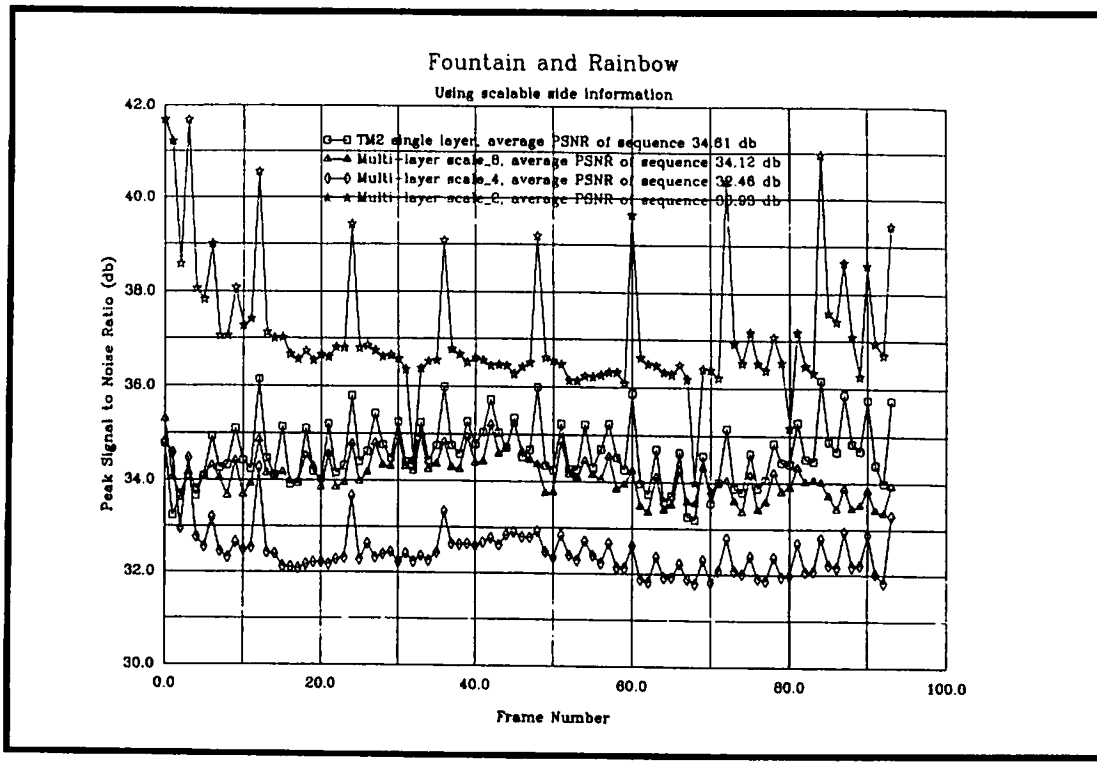

Figure 2: PSNR profile for SL and three layer scalable side information implementation SSI.

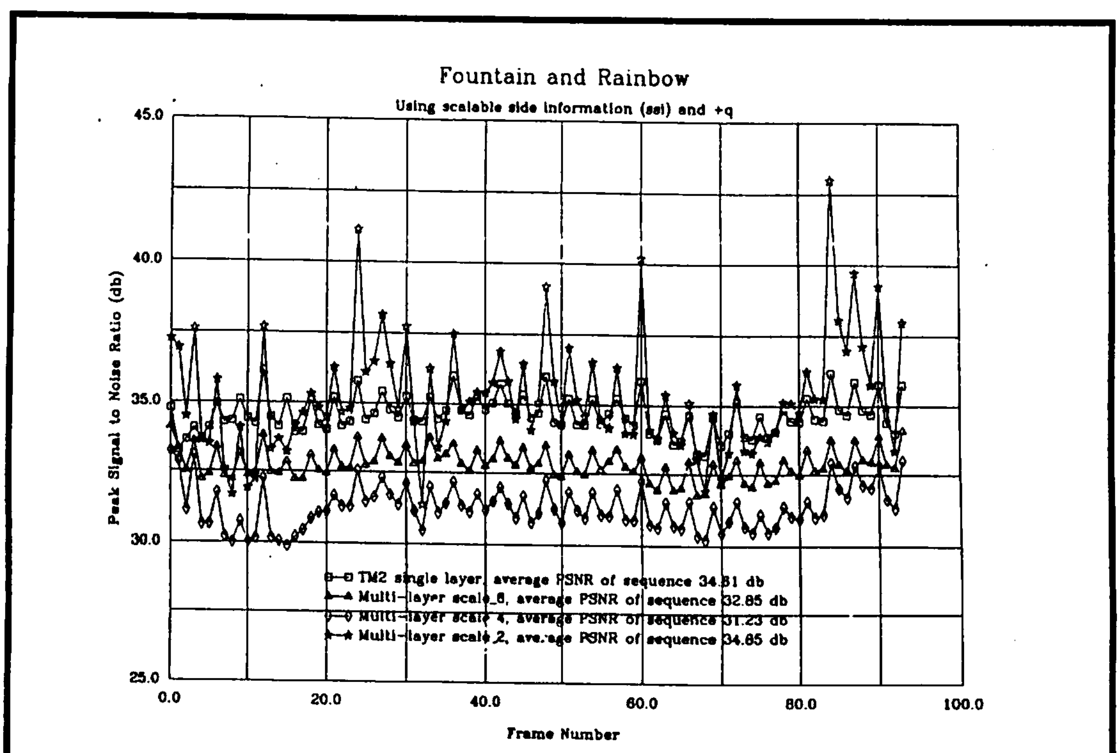

Figure 3: PSNR profile for SL and three layer scalable side information implementation SSI+Q.