ISO/IEC JTC1/SC29/WG11
MPEG93/ 396
March 1993

Telecommunication Standardization Sector
Study Group 15
Experts Group for ATM Video Coding
(Rapporteur's Group on Part of Q. 2/15)

Document AVC-452
March 18, 1993

SOURCE : Japan

TITLE : Syntax modification for VBR operation

PURPOSE : Proposal and discussion

Relevant sub-group: Video

1. Introduction

Coding in a Variable Bit Rate (VBR) environment is included in the main profile. The effect and requirement of VBR operation to the syntax should be clarified. Some modifications are proposed, and regulation of vbv_delay for VBR operation is discussed.

2. Parameters to be modified

Syntax parameters which are specific to VBR operation are as follows.

(1) "bit_rate" in sequence header

This parameter is set all "1" in the current rule[1], and this can be a flag of the VBR mode. In VBR operation, however, there are many quality classes according to bit-rate settings such as peak bit rate and average bit rate. Considering this situation, the VBR flag should be explicitly indicated, and at least two kinds of bit rates should be distinguished. The proposed modification is as follows:

Current description				Modified description		
				vbr_mode	1 bit	uimsbf /* 0: CBR, 1: VBR */
bit_rate	18 bits	uimsbf	→	bit_rate	18 bit	uimsbf /* normal bit rate in CBR, peak bit rate in VBR */
				ave_rate	18 bit	uimsbf /* 3FFFF in CBR, average bit rate in VBR */

(2) "vbv_buffer_size" in sequence header

Currently "vbv_buffer_size" is a 10-bit integer. In VBR operation a larger buffer is needed in some cases.

(i) encoder buffer

(a) When coded data which emerge from the encoder can be transmitted immediately, only a packetizing buffer is required. That is much smaller than the buffer in constant bit rate (CBR) operation, and a 10-bit integer for "vbv_buffer_size" is sufficient.

(b) When coded data of one picture is stored in the encoder buffer such as in the model case of vbv_delay analysis[2], the buffer size of the VBR encoder is somewhat larger than that of a CBR encoder because VBR operation allows more fluctuation of the amount of coded data.

When bursting ratio is denoted as "bst", "vbv_buffer_size" should be $10 + \log_2 bst$ bit (the parameter "bst" is the ratio of the allowed maximum number of bits per picture in VBR against the number of bits per picture in CBR when the average bit rates are the same in both cases).

(c) When coded data of several (L) pictures is stored in the encoder buffer such as in the case described later in (3)(i), buffer size should be much larger. "vbv_buffer_size" should be $10 + \log_2 bst + \log_2 L$.

Note: Since the encoder can select transmission bit rate, picture skipping to decrease the buffer delay is not necessary in principle, and the target value of buffer control (Bl) can be much smaller than that in CBR operation (See Figure). However, when there is a limitation of maximum transmission bit rate due to hardware capacity or the UPC of the network, picture skipping to prevent the encoder buffer overflow may become necessary.

(ii) decoder buffer

(a) When received data in decoder buffer is decoded in a time shorter than one picture period, for example, in every macro block, only a small size of decoder buffer is needed, and a 10-bit integer for "vbv_buffer_size" is sufficient. In this case, however, an operation verifier of the decoder buffer such as "vbv_delay" is required in every macro block. This would involve another major modification of syntax and some decrease of coding efficiency.

(b) When received data in the decoder buffer is decoded picture by picture as in the current model of CBR operation, the decoder must have a buffer with a size of $10 + \log_2 bst + \log_2 L$ to prevent buffer overflow. This is shown by Eq. 3 on the next page.

As a conclusion, in the worst case the encoder and the decoder must have buffers with a size of **$10 + \log_2 bst + \log_2 L$**. When bst=8 and L=8 as practical values, **16 bits** are required for "vbv_buffer_size".

(3) "vbv_delay" in picture layer

In the current rule "vbv_delay" is set to all "1" in VBR operation. However, some verifier to initialize decoder operation is necessary also in VBR.

Decoder buffer occupancy is expressed by the following parameters[3] (See Figure):

B_i^e : encoder buffer occupancy

B_i^d : decoder buffer occupancy

E_i : coded bit amount

R_i : transmitted bit amount

L : time delay from starting to receive the first picture to decoding the first picture

At the encoder,

$$B_i^e = B_{i-1}^e + E_{i-1} - R_{i-1}$$

Initial occupancy of encoder buffer, $B_1^e = 0$ (assumption)

$$\therefore B_i^e = \sum_{j=1}^{i-1} E_j - \sum_{j=1}^{i-1} R_j \quad \text{------ Eq. 1}$$

Meanwhile, at the decoder

$$B_i^d = B_{i-1}^d + R_{i-1+L} - E_{i-1}$$

$$B_1^d = \sum_{j=1}^{L} R_j$$

Initial occupancy of decoder buffer = 0 (assumption)

$$\therefore B_i^d = \sum_{j=1}^{i-1+L} R_j - \sum_{j=1}^{i-1} E_j \quad \text{------ Eq. 2}$$

From Eq. 1 and Eq. 2,

$$B_i^d = \sum_{j=i}^{i-1+L} R_j - B_i^e \quad \text{------ Eq. 3}$$

According to Eq. 3, several approaches to set the "vbv_delay" are possible.

(i) To obtain a precise value of decoder buffer occupancy B_i^d, the encoder has to wait L picture-times because transmission bit rates for those L picture-times are necessary. This causes buffering delay. In this approach, however, precise values of B_i^d and vbv_delay (D_2 for a picture F_2 in the Figure) can be calculated by the following scheme and indicated at the top part of every picture.

"t_i" satisfying the following equation can be found.

$$B_i^e = \int_{iT}^{t_i} \rho(t)\, dt \quad (iT \le t_i \le iT+LT) \quad \text{------ Eq. 4}$$

$\rho(t)$: transmission rate, $\int_{(i-1)T}^{iT} \rho(t)\, dt = R_i$

T : one picture-time

t_i : time when picture header crosses the horizontal axis, or picture header is transmitted from the encoder

Then

$$D_i = iT+LT - t_i \quad \text{------ Eq. 5}$$

D_i : vbv_delay

(ii) To avoid the buffering delay of approach (i), transmission bit rates have to be decided before coded data is really transmitted. For example in the figure, R_2 and R_3 have to be decided just before a picture F_2 is coded. This approach requires a sophisticated scheme for controlling and planning transmission bit rates. Based on the predicted transmission bit rates, B_i^d and vbv_delay can be calculated in the same way as for approach (i).

(iii) In quite a different approach, a fixed vbv_delay can be used. When the coding bit rate and transmission bit rate are almost constant, for example, when R_i = peak transmission rate × T, and the amount of coded data per picture is controlled to be less than R_i with allowing buffer underflow, the decoder can start decoding just after waiting a time T, after the picture header has reached the decoder buffer. This approach is quite simple. However, sophisticated coding rate control and transmission rate control is required.

3. Conclusion

Syntax modifications essential to VBR operation have been proposed. Regulation of "vbv_delay" needs further study.

REFERENCES

[1] MPEG-2 Working Draft, MPEG 92/981, AVC-446, December 1992.

[2] Japan, AVC-451, March 1993.

[3] B. G. Haskell and A. R. Reibmen, "Constraints on Variable Bit-Rate Video for ATM", AVC-56, May 1991.

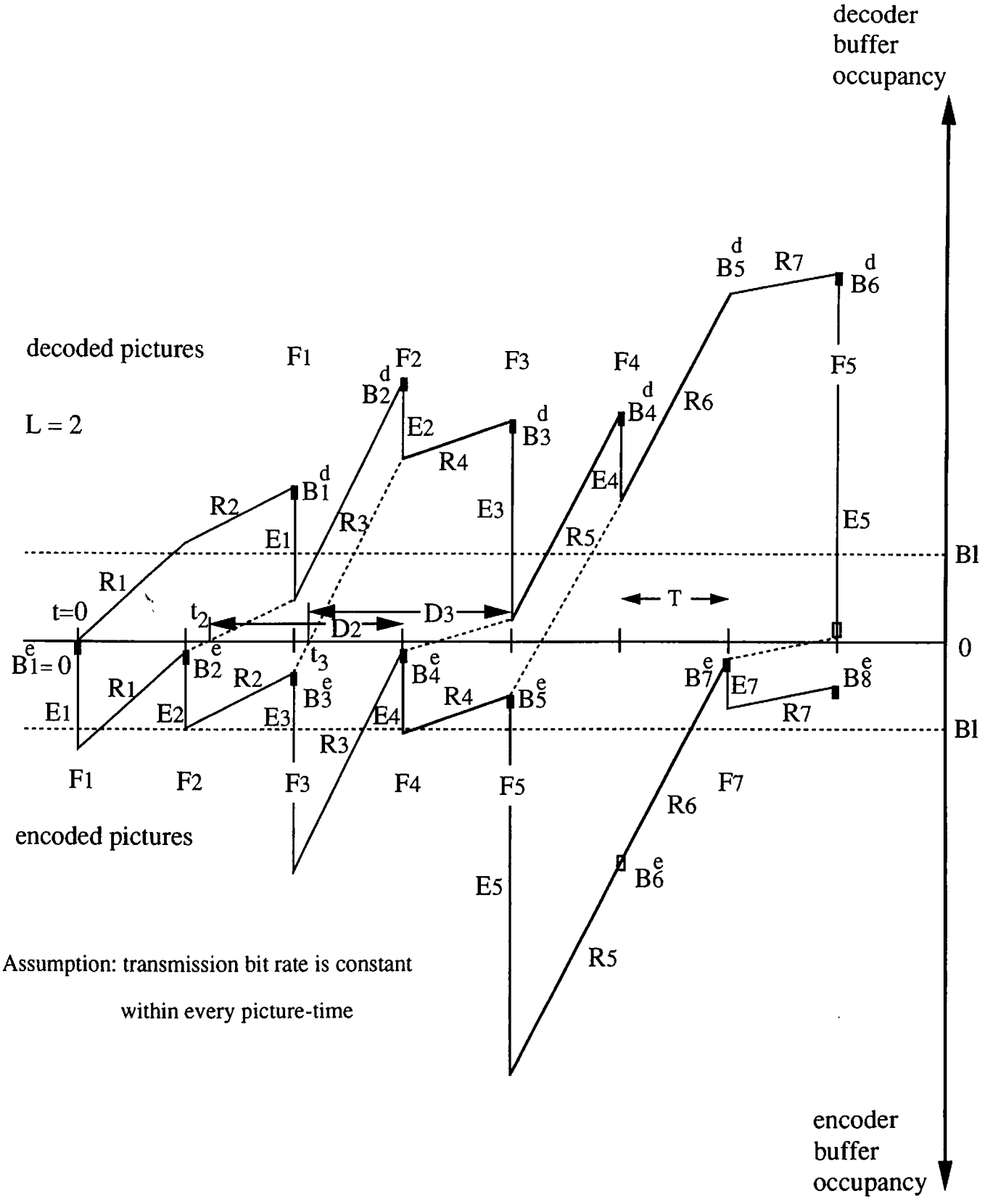

Figure: Buffer occupancy in VBR operation