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Source: Japan
Title: **bit_rate** field in VBR operation
Purpose: Discussion and Proposal
Relevant MPEG sub-groups: Video, Systems

Abstract

This document intends to clarify the VBR operation in H.262|ISO/IEC 13818-2 based on the CD texts, raising the following questions; **bit_rate** values that can be written when **vbv_delay** = FFFF, wording for the **bit_rate** semantics, transport buffer size, and start-up delay for the multiplex buffer.

1. Introduction

This document addresses the value which can be written in the **bit_rate** field when H.262|ISO/IEC 13818-2 video codecs are operated in VBR mode. There are two different restrictions in designing the encoder operational parameters;

- restriction due to the network usage parameter control,
- restriction due to the decoder capability.

The current subject is the second restriction. For the first restriction, it is sufficient for the moment that not only peak rate but also average rate should be regulated according to the definition of "traffic descriptor" which specifies coded video information flow at the user-network interface. Frame structure and 29.97 Hz frame rate are assumed also for discussion simplicity.

An MP@ML decoder is assumed, which can handle up to 15 Mbit/s in CBR operation. The question is what this "15 Mbit/s" means to the VBR encoder, or what variable bit rate streams we can generate so that the MP@ML decoder can successfully reproduce the coded pictures without crashing.

2. bit_rate field definition for VBR mode

VBR **bit_rate** field is characterized by the Transport Stream System Target Decoder (T-STD), as mentioned in the semantics of **bit_rate**; "the T-STD specifications supersede the VBV, and the bit_rate specified here is used to dimension the T-STD" [1]. Dimensioning the T-STD is to determine Res(max) and the multiplex buffer size as defined below.

Section 2.4.2 of ISO/IEC 13818-2 describes the operation of T-STD, which has three different buffers [2];

- "transport buffer" of size 512 bytes, which is for instantaneously transferring coded data to the multiplexing buffer in unit of a 188 bytes packet,

- "multiplexing buffer" of size 4 ms *(188/184) * Res(max) which is continuously read out at rate Res(max), or the peak rate and is given by the **bit_rate** field.

- "Video Buffering Verifier" of size **vbv_buffer_size**, which is for instantaneously transferring coded data to the decoder in unit of a picture.

Though the Systems CD describes the second and third buffers together as main buffer, they are separated here for better understanding.

3. T-STD operation

The T-STD buffer operation is illustrated in Figure 1. A segment of the PES packet is inserted in the payload of the nearest available TS packet here.

The TS packet is removed at a time Ln after 94 bytes have been received. It is interpreted that the transport buffer starts up with empty condition when it begins to receive TS packet #0. Figure 1 is for a case of transport_rate/Res(max)=1.4, hence a video TS packet is removed 3.3 Ttp after its first byte has arrived at the input of the Transport buffer. It should be noted that the transport buffer overflows in this case. If we intend to prevent the transport buffer overflow, the throughput reduces to 2/3 of the transport_rate.

Though the start-up operation of the multiplex buffer is not described in the Systems CD, it should start to remove the buffered data at a time Ttp after the first TS packet is instantaneously input to the empty buffer. This start-up delay is necessary to prevent the multiplex buffer underflowing, and should be taken into account when determining the total system delay.

The third buffer, VBV, works for VBR video in the same way as for CBR video. Hence we can think of a video decoder consisting of "buffer" and "decoding kernel", where "decoding kernel" needs not distinguish whether the coded video data residing in the "buffer" has come from a CBR coder or a VBR coder. In either case, a certain number of bits are instantaneously fed to the decoder once every frame period.

4. Decoder implementation

The MP@ML decoder should have VBV buffer size of more than 1,835,008 Mbits and can operate up to 30 Hz frame rate. It means that the largest possible frame contains 1.835 Mbits, namely the "decoding kernel" can accept a bitstream equivalent to 55.05 Mbit/s rate, at least for a frame period. If the decoding kernel can process this largest picture in 1/30 second, then it may be able to accept coded video with 1.835 Mbits in *every* frame.

If the above is true, then for VBR operating MP@ML decoders we can write **bit_rate** field with a value up to 55.05 Mbit/s.

Next consideration is regarding the "buffer". For CBR operation, the input to the VBV buffer is limited to 15 Mbit/s. If the MP@ML decoder implementation is utilizing this fact, then it can not accept VBR bitstreams with peak rate of 55.05 Mbit/s even if the "decoding kernel" can handle them. Particularly, memory bandwidth may be a limiting factor if the buffer and the frame store share the same memory. Some designs may use different memory chips for the buffer and frame store; the buffer input higher than 15 Mbit/s may not be restricting in this case.

5. Discussion

The above considerations are summarized in the following two questions;

Q.1) Can MP@ML decoders process coded bitstreams with 1.835 Mbits in every frame?
Q.2) Can input rate of the MP@ML decoder be up to 55.05 Mbit/s?

If both answers are yes, we can say that the maximum value for VBR **bit_rate** field is 55.05 Mbit/s for the MP@ML decoder. Note that a VBR bitstream is identified by vbv_delay = FFFF in hexadecimal.

Our discussion in the ITU-T Japan group reached a conclusion that the answers largely depend on implementation and that restricting the buffer input rate as up to 15 Mbit/s even for VBR is safer and more appropriate.

One of the VBR merits is to reduce buffering delay by transferring every coded frame data to the decoding kernel within a frame time (Figure 2)[3]. In this operational mode, limiting the buffer input rate to 15 Mbit/s implies that the maximum number of bits per frame is limited to 15 Mbit/s *1/30 sec = 500 kbits per frame, and that if peak/average ratio = 4, the average rate is limited to 3.75 Mbit/s. If we intend to have more flexibility in the information generation at the coder, e.g. to obtain statistical multiplex gain, it should be traded off against delay which is indicated by the time stamps [4].

6. Conclusion

The following points are listed which need clarification in the Video and Systems specifications;

1) Values which can be written in **bit_rate** field in VBR operation; the same maximum values as for CBR are proposed- Video
2) Wording for VBR coded data rate in Chapter 8 (see the companion document AVC-615) - Video
3) Transport buffer size; 512 Bytes are sufficient? - Systems
4) Start-up delay for the multiplex buffer - Systems

END

References

[1]	AVC-600	Video CD ISO/IEC JTC1/SC29 N659 (WG11 Editorial Group), Clause 6.3.3	Dec 1993
[2]	AVC-601	Systems CD ISO/IEC JTC1/SC29 N658 (WG11 Editorial Group), Clause 2.4.2	Dec 1993
[3]	AVC-591	Comments on vbv_delay description in variable bitrate operation (Japan)	Oct 1993
[4]	AVC-598R	Annex 4 (or MPEG93/965) Decoding start-up algorithm for VBR coded video (Experts Group)	Oct. 1993

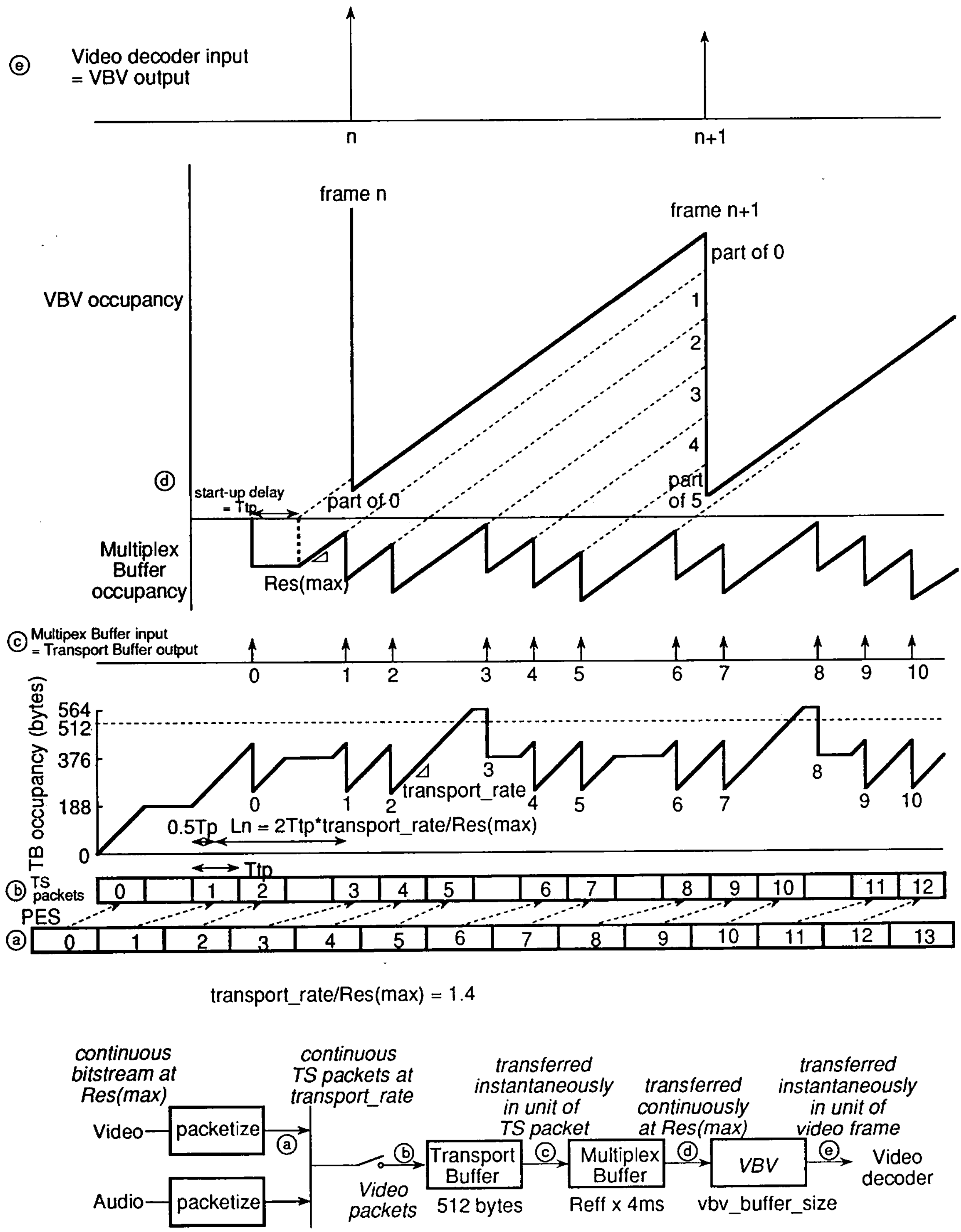

Figure 1 T-STD operation

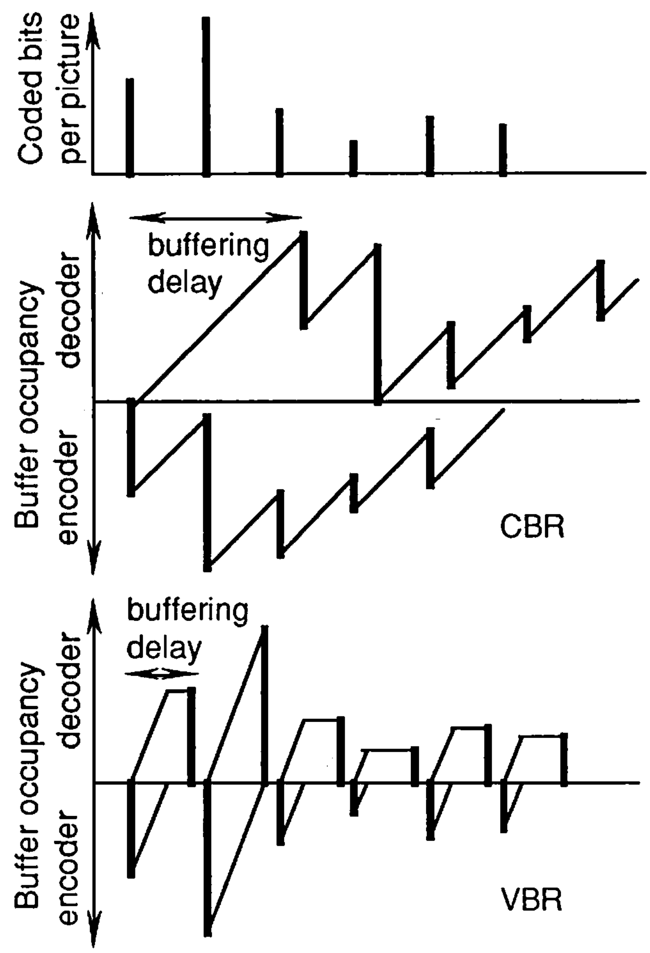

Figure 2 Buffering delay of CBR and VBR