CCITT SGXV
Working Party XV/I
Experts Group for ATM Video Coding

Document AVC-90
August 1, 1991

SOURCE : Japan
TITLE : Considerations on delay with VBR coding
PURPOSE : Discussions

1. Introduction

The transmission delay is considered when VBR coding scheme is employed. There is a general expectancy that the end-to-end delay, which is an important factor in conversational services, can be reduced by using VBR coding instead of CBR coding. But, the detailed analysis on this matter is still limited. In this document, requirement for (1) encoder buffer size and (2) peak bit rate is given as a function of average bit rate and window size for monitoring the average.

2. Assumptions for simplification

- A frame is considered to be a unit of operations for encoder/decoder.
- Encoding for a frame finishes as soon as the input frame is given completely to the encoder, and at that moment all the encoded data is transferred to the output buffer instantly.
- The amount of encoded data for each frame is controlled by a scheme not specified here so that the average bit rate measured with the monitoring window size is always less than the declared value.
- The encoder output buffer is read out at the peak rate as long as it is not empty.
- Decoding for a frame finishes when a last encoded bit for that frame is received, and at that moment the decoded video signal is transferred to the display buffer instantly.

3. Discussions

- The transmission of the encoded data at the peak rate is guaranteed by the assumption that the average bit rate is always controlled below the declared value.
- Defining T [sec] as the duration of one uncoded frame, i.e., either 1/30 [sec] or 1/25 [sec], the maximum allowable amount of encoded data for one frame, F_{max} [bit], is given by

$$F_{max} = Ave \cdot S_{win}, \tag{1}$$

where Ave [bit/T] is average bit rate per frame period, and S_{win} [T] is window size in frame period. This largest frame size occurs when the transmission capacity during a window interval is all allocated to only one frame.

- The size of the encoder output buffer, S_{buf} [bit], therefore, must satisfy

$$S_{buf} = F_{max}. \tag{2}$$

- Maximum delay for transmitting one frame, L [T], which is measured in frame period T, is given by

$$\begin{aligned} L &= F_{max}/Peak & (3)\\ &= \left(\frac{Ave}{Peak}\right) \cdot S_{win}, & (4) \end{aligned}$$

where $Peak$ [bit/T] is peak bit rate per frame period.

- To maintain a constant frame rate operation without any frame skipping nor repetition, all the frames must experience the same amount of delay, which must be equal to L [T].

4. Comparison with AVC-56 [1]

- where buffering occurs
  - In AVC-56, buffering occurs in both encoder output buffer and decoder input buffer where encoded data are stored. The total amount of encoded data to be stored in either buffer is equal to $L \cdot R_{ave}(L)$ [bit], where $R_{ave}(L)$ is average bit rate measured during the last L frame period, the rate being governed by some control scheme.
  - In this document, buffering occurs mostly in encoder output buffer, where encoded data with maximum size of S_{buf} [bit] is stored, and in display buffer, where decoded picture is stored with maximum number of pictures equal to L.
- average rate control
  - Leaky bucket is used as an example. (AVC-56)
  - Sliding window is assumed. (this doc.)
- buffer overflow/underflow
  - Encoder output buffer overflow is less likely to happen than in CBR coding, because the virtual encoder buffer size (i.e., bucket size + actual encoder buffer size) is much larger than the encoder buffer size in CBR. On the contrary, the necessity for preventing decoder input buffer overflow may impose a constraint for using a variable bit rate channel. (AVC-56)

– No problem if the encoder/decoder buffer size requirement mentioned above is satisfied, and the average rate control scheme works properly. (this doc.)

5. Conclusions

Delay with VBR coding is discussed. The size of the encoder output buffer and required peak bit rate to limit the maximum delay to a given amount are obtained.

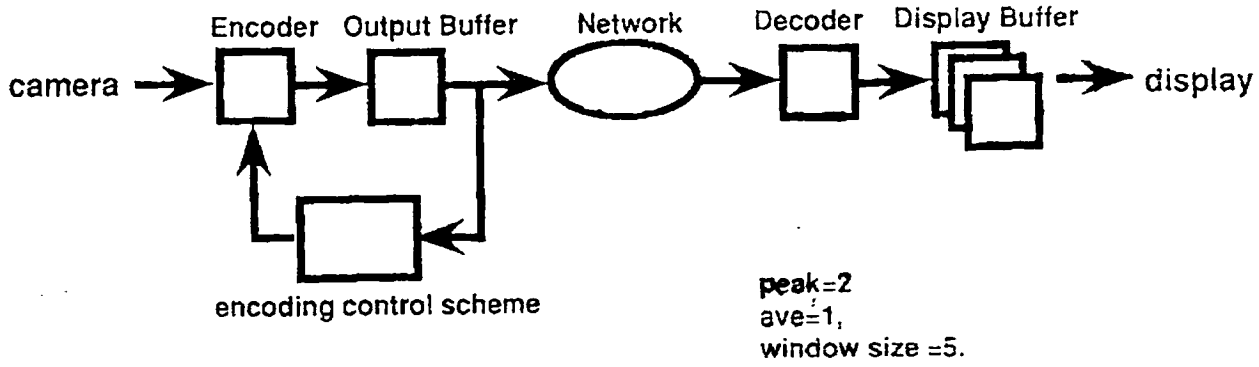
Reference

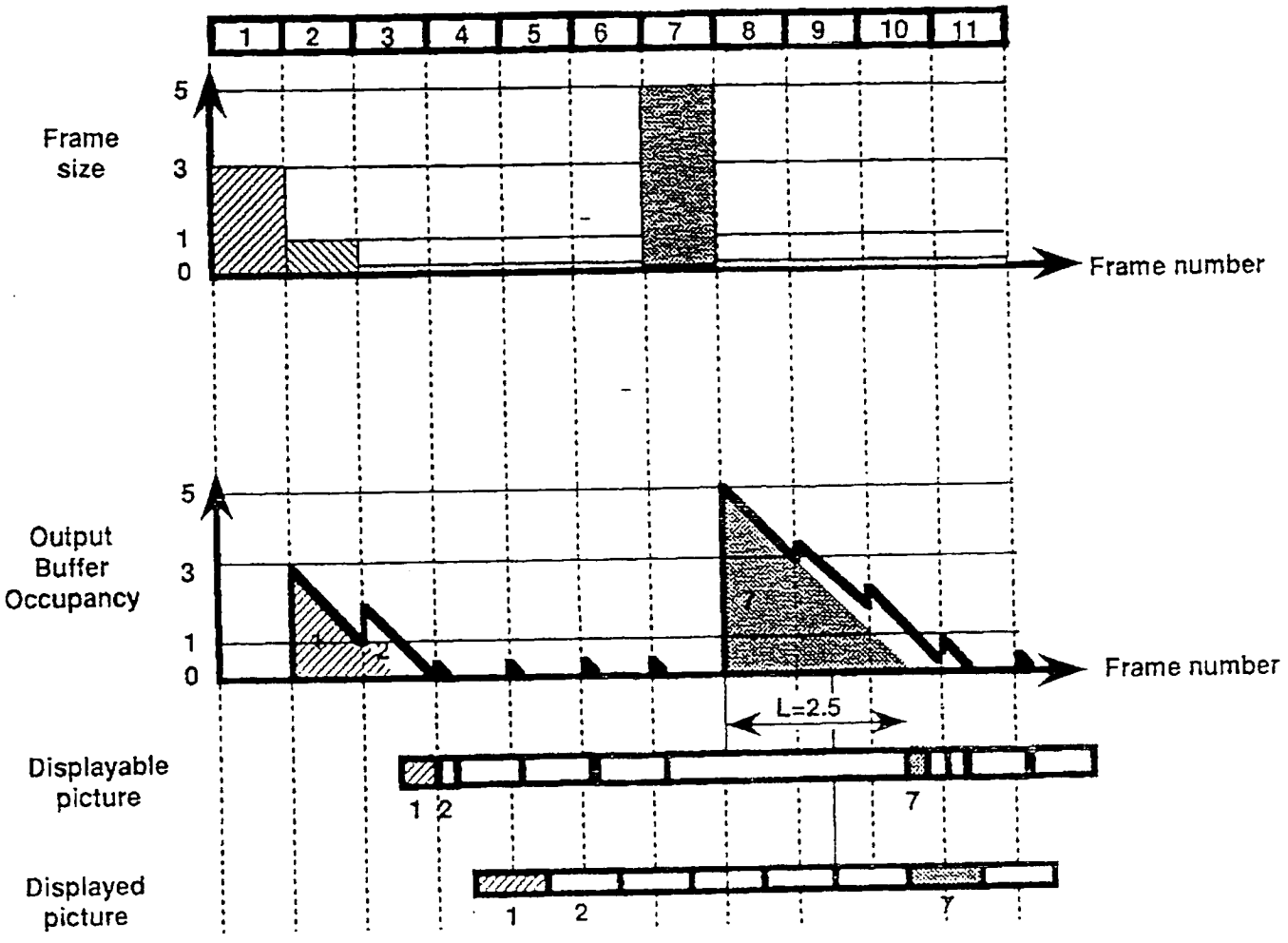
[1] AVC-56, "Constraints on Variable Bit-Rate Video for ATM Networks", AT&T Bell Labs, Paris, 23-24 May 1991.

Annex 1

Example diagram for explaining the relationship between the peak bit rate and the maximum frame size, etc.

Annex 1 to AVC-90





Example diagram for explaining the relationship between peak bit rate and maximum frame size, etc.