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

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TITLE : VBR Coding and Octet Interleave
PURPOSE : Information

1. Introduction

Octet interleaving combined with forward error correction mitigates the effect of cell losses, but it also creates an extra delay at an interleave matrix.

In CBR coding, this delay is bounded, or actually a constant, determined by the (average) bitrate. However, in VBR coding, the instantaneous bitrate varies depending on the activity of the scene, and therefore, the delay can be very large if the scene has very small activity.

This document discusses two techniques to solve this problem.

2. Octet interleaving and VBR coding

In CBR coding, octet interleaving is being discussed as a function of an AAL to mitigate the effect of cell losses[1]. Error resilience is obtained in exchange for the extra delay that is proportional to the interleave matrix size divided by the (average) bitrate.

When such techniques are also applied to VBR coding, there will be one problem that the delay incurred at the interleave matrix can be infinitely large during the period in which the instantaneous bitrate is very small.

Two techniques can be applicable to solve the problem.

Solution 1

> One method is to assume and keep some minimum bitrate such that the instantaneous bitrate will never go below that value. If the minimum bitrate is set to be, for example, half the (nominal) average bitrate, the interleave delay is bounded to be twice as much as the delay observed with CBR coding with the same average bitrate.

Solution 2

> Another method is to have a time–out in AAL that flushes an interleave matrix, even if it is not full. In this case, the delay can be upperbounded arbitrarily by choosing the timer values.

Since the minimum bitrate can only be maintained by padding fill bits, and since a flush operation also implies sending some fill bits, the coding efficiency decreases as one tries to lower the interleave delay.

The following sections show the hardware experiment parameters and its results on how much the (actual) average bitrate increases (Open-loop Experiment) and on how much the average quantizer stepsize increases (Closed-loop experiment).

Through out the experiment, a leaky bucket is used as a means for UPC.

3. Experiment Parameters

The interleave matrix size is assumed to be equal to 16 cells (= 768 bytes) [2], which corresponds to 4.0 mSec of delay in the case of 1.5 Mbps CBR operation.

Other experimental parameters are the same as in [3] and [4], namely;

- Coding Algorithm
  - H.261
- Picture Format and Picture Sequence Length
  - one CIF sequence of 10 minutes (18,000 frames) duration
- UPC method
  - Peak Bitrate : 6Mbps
  - Average Bitrate and control method: 1.5Mbps with Leaky Bucket Control
  - Bucket Size: 16.777×10^6 Octet / 1.728×10^6 Octet / 172.8×10^3 Octet
  - Max duration for Peak rate: 29 sec / 3 sec / 0.3 sec
    (e.g.,= $16.777 \times 10^6 \times 8/(6\text{Mbps} - 1.5\text{Mbps})$)
- Coding parameters control method
  - VBR mode (if Leaky Bucket Occupancy $\leq$ 90% of Leaky Bucket Size)
    $\Longrightarrow$ Constant Quantizer Stepsize and Constant Picture Quality.
  - CBR mode (otherwise)

4. Experiment Results

4.1 Conventional VBR operation

Figure 1 shows the cumulative distribution function of instantaneous bitrate values, averaged over a frame period. The peak bit rate is 6 Mbps and the (nominal) average bitrate is controlled to be 1.5 Mbps, but there is no guaranteed minimum bitrate nor no flush operations (conventional VBR operation).

From the figure, it is observed that if one imposes the minimum guaranteed bitrate of, say, 1 Mbps, (= 2/3 times the nominal average bitrate), the padding must occur with about 25% of the coded frames, and that the average rate of the fill bit will be around 128 kbps, ($= 0.5 \cdot 1\text{Mbps} \cdot 25\%$). In other words, the 8.3% increase of the bitrate from the nominal average bitrate of 1.5 Mbps is expected.

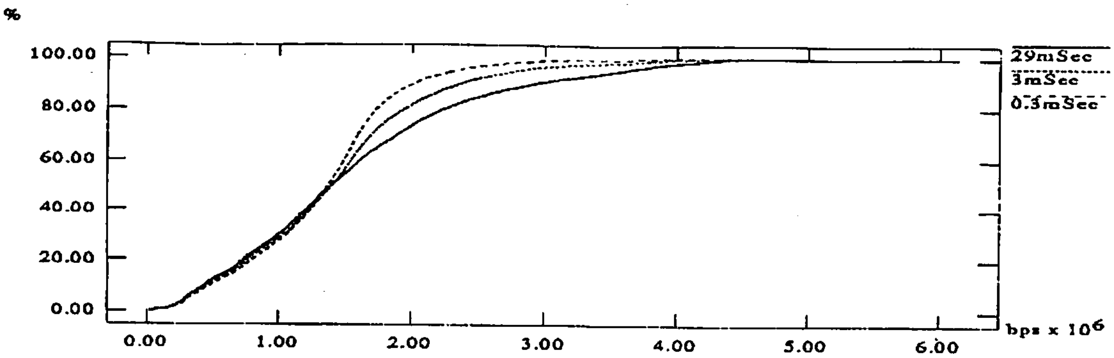


Figure 1: Cumulative distribution for one frame averaged bitrate.

4.2 With guaranteed minimum bitrate

Table 1 shows both an open–loop and a closed-loop experiment with a guaranteed minimum bitrate.

Table 1: Bitrate increase / Fill bit percentage for guaranteed minimum bitrate.

	maximum peak duration	guaranteed minimum bitrate 512kbps (12 mSec)	768kbps (8 mSec)	1Mbps (6 mSec)
open loop	29 sec	1.7%	5.0%	10.1%
	3 sec	1.7%	4.9%	9.8%
	0.3 sec	1.7%	4.7%	9.7%
closed loop	29 sec	1.5%	4.1%	8.6%
	3 sec	1.6%	4.4%	8.6%
	0.3 sec	1.6%	4.2%	9.0%

Table 2: Averaged quantizer stepsize for closed-loop experiment.

maximum peak duration	no guarantee	guaranteed minimum bitrate 512kbps (12 mSec)	768kbps (8 mSec)	1Mbps (6 mSec)
29 sec	5.90	6.13 (+0.23)	6.41 (+0.51)	6.86 (+0.96)
3 sec	6.70	6.76 (+0.06)	6.80 (+0.10)	7.17 (+0.47)
0.3 sec	7.56	7.55 (-0.01)	7.47 (-0.09)	7.52 (-0.04)

In open-loop cases, there is actually up to 10% increase in the bitrate, as is expected from Figure 1, in which the quantizer stepsizes are kept equal to a conventional VBR case.

In closed-loop cases, the average bitrate does not increase, but up to 9% of the bitrate is occupied by fill bits, and as a consequence, the average step sizes increased 0–1.0 as shown in Table 2.

It is observed that if the leaky bucket size is reasonably small, the increase in quantizer step size is very close to zero.

4.3 With flush operations with a timer

Table 3 shows a closed-loop experiment with flush operations. The percentage of the fill bits increases gradually as the timer value, thus also a delay, decreases, but it is only around 3% even if the time-out value is as small as 8.3 mSec.

Table 4 shows the increase of the average quantizer step size for each case.

Table 3: Fill bit percentage for timeout flush operation.

maximum	timeout value				
peak duration	33mSec	25mSec	16.7mSec	11.1mSec	8.3mSec
29 sec	0.026%	0.094%	0.543%	1.712%	3.409%
3 sec	0.030%	0.104%	0.565%	1.755%	3.691%
0.3 sec	0.028%	0.088%	0.541%	1.857%	3.856%

Table 4: Averaged quantizer stepsize for timeout flush operation.

Maximum	timeout value					
peak duration	∞	33mSec	25mSec	16.7mSec	11.1mSec	8.3mSec
29 sec	5.90	5.89(-0.01)	5.90(±0)	6.10(+0.20)	6.73(+0.83)	7.41(+1.51)
3 sec	6.70	6.62(-0.08)	6.64(-0.06)	6.80(+0.10)	7.05(+0.35)	7.17(+0.47)
0.3 sec	7.56	7.34(-0.22)	7.40(-0.16)	7.61(+0.05)	7.68(+0.12)	7.66(+0.10)

5. Discussions

Both Solutions 1 and 2 are effective in reducing the delay at an interleave matrix.

The negative effect, increase of the average quantizer step size, of the solutions is found to be small, especially if there is more strict UPC control, in which VBR coding tends to approach CBR coding.

6. Conclusions

This document discussed techniques to extend the applicability of octet interleaving to VBR coding. Although it is shown that the octet interleaving can also be used in VBR coding with minimum loss in coding efficiency, specific parameter values such as the assured minimum bitrate or the timer value must further be optimized depending on the actual environment.

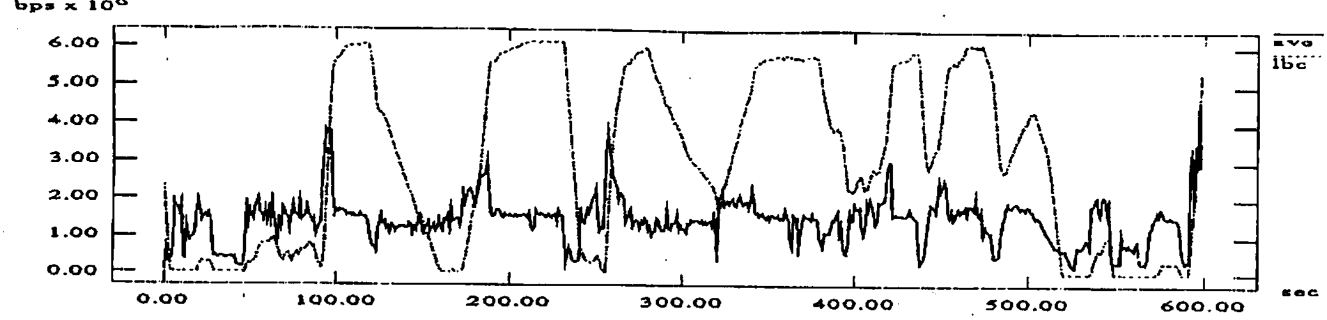
7. References

[1] CCITT I. 363, B-ISDN ATM Adaptation Layer (AAL) Specification

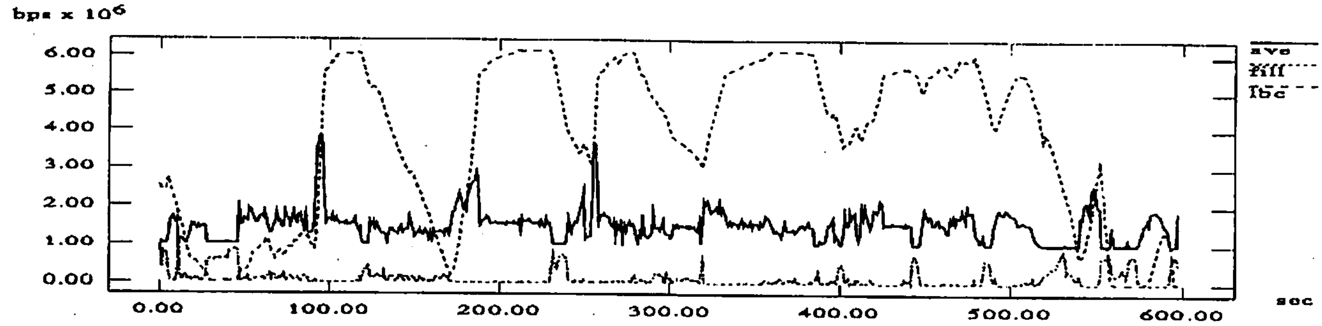
[2] AVC–521, Correction method for cell loss and bit error in AAL Type 1, July 1993

[2] AVC–372, VBR Coding under Usage Parameter Control, October 1992

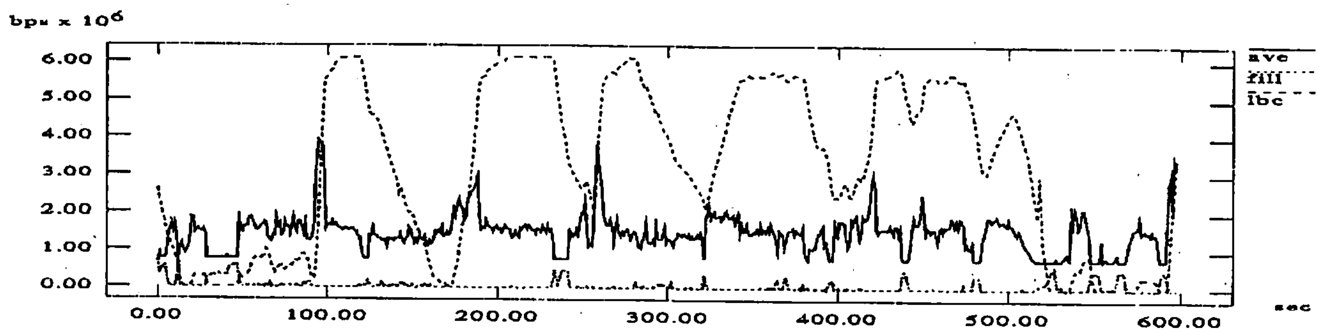
[3] AVC–462, VBR Coding under Usage Parameter Control (Part 2), March 1993



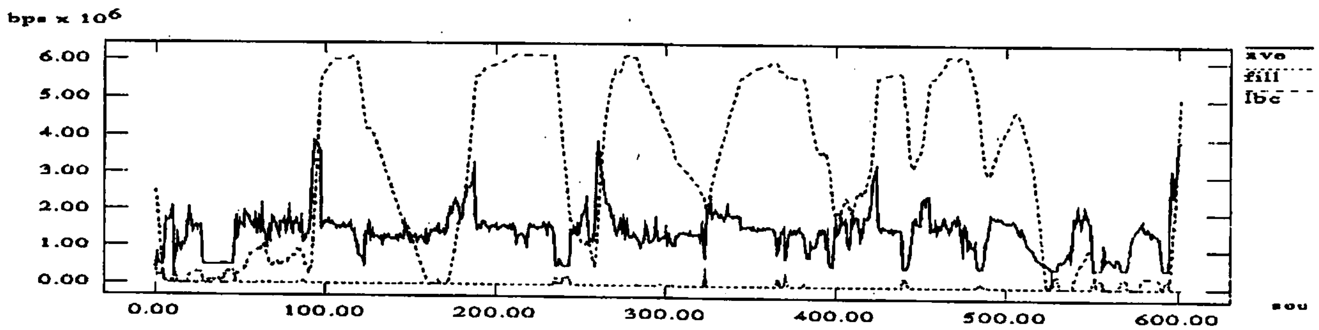
(a) no minimum bitrate guarantee



(b) 1Mbps minimum guarantee

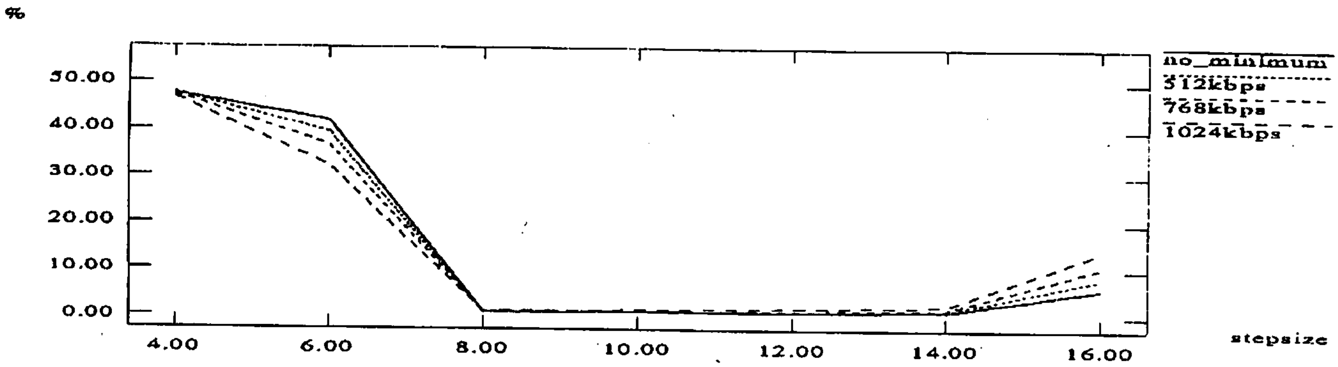


(c) 768kbps minimum guarantee

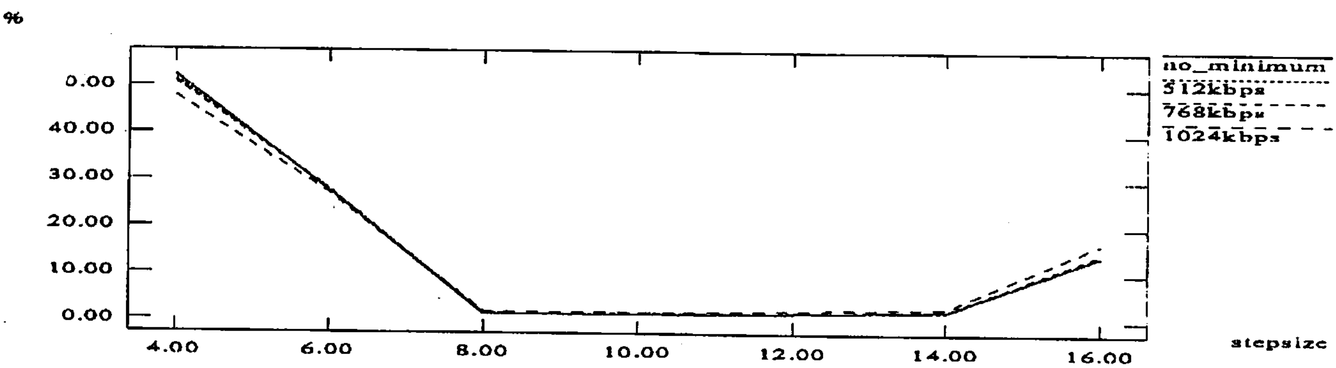


(d) 512kbps minimum guarantee

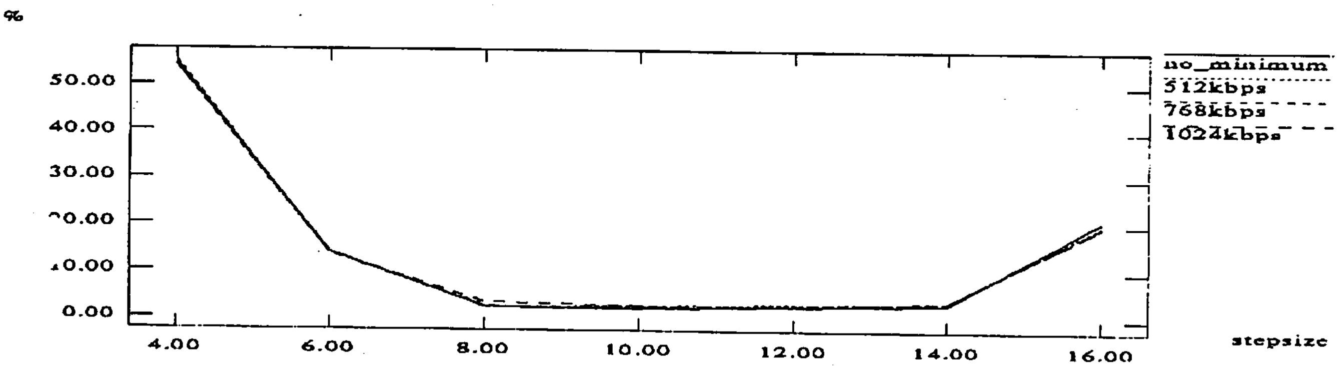
Figure 2: One second averaged bitrate, filled bitrate and leaky bucket transition for 3mSec maximum peak duration.



(a) Maximum peak duration : 29mSec

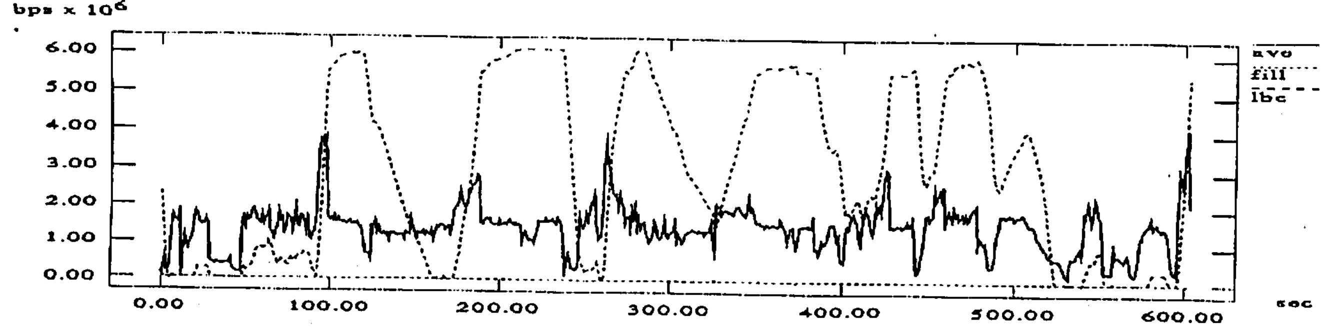


(b) Maximum peak duration : 3mSec

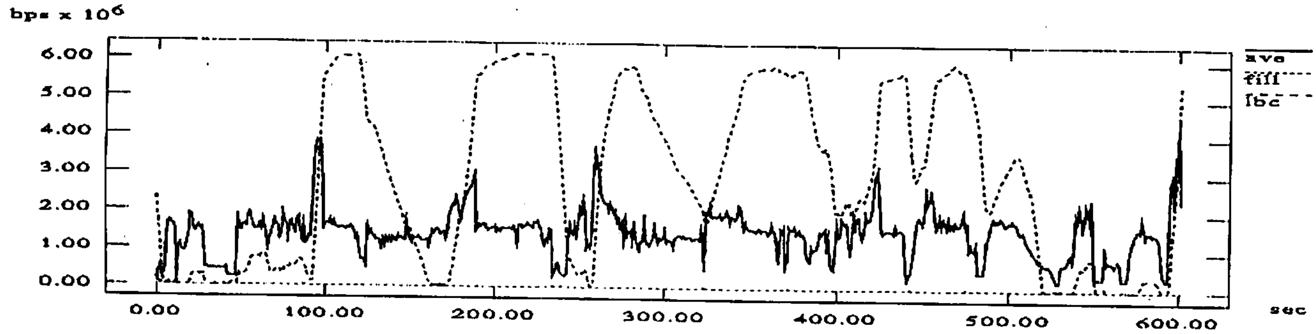


(c) Maximum peak duration : 0.3mSec

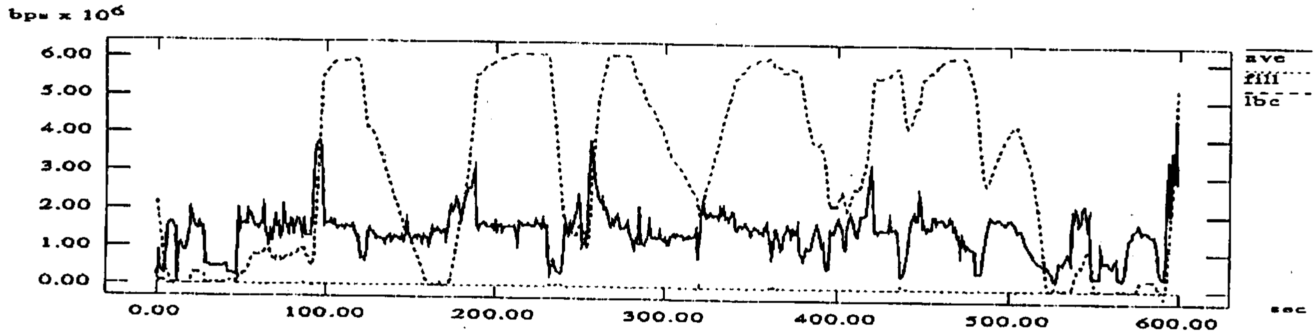
Figure 3: Average quantizer stepsize for minimum bitrate guarantee.



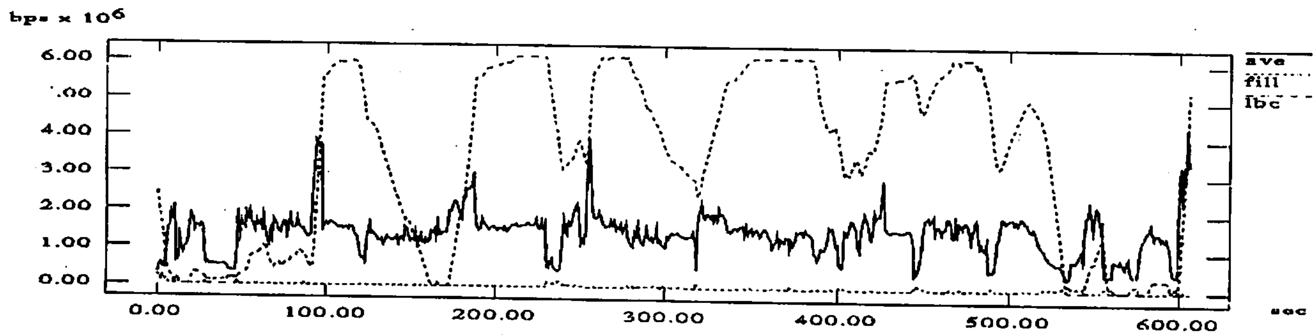
(a) 33mSec timeout



(b) 25mSec timeout

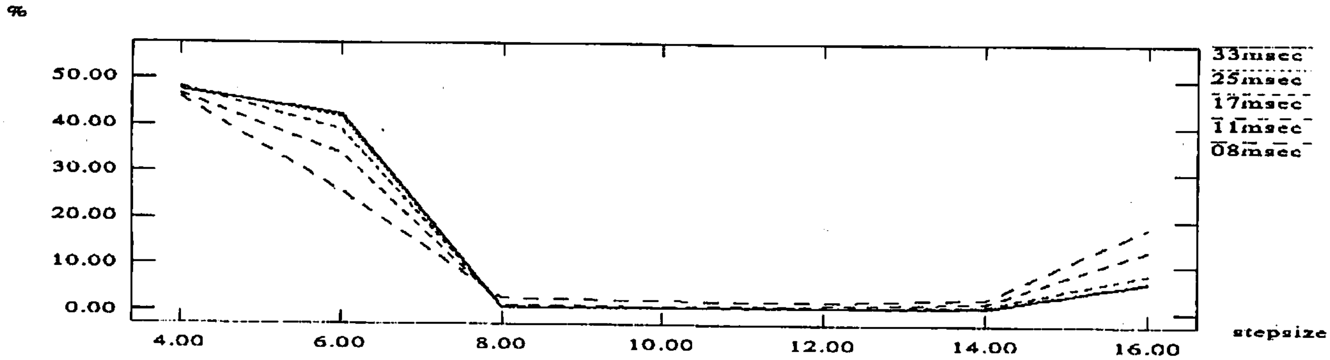


(c) 16.7mSec timeout

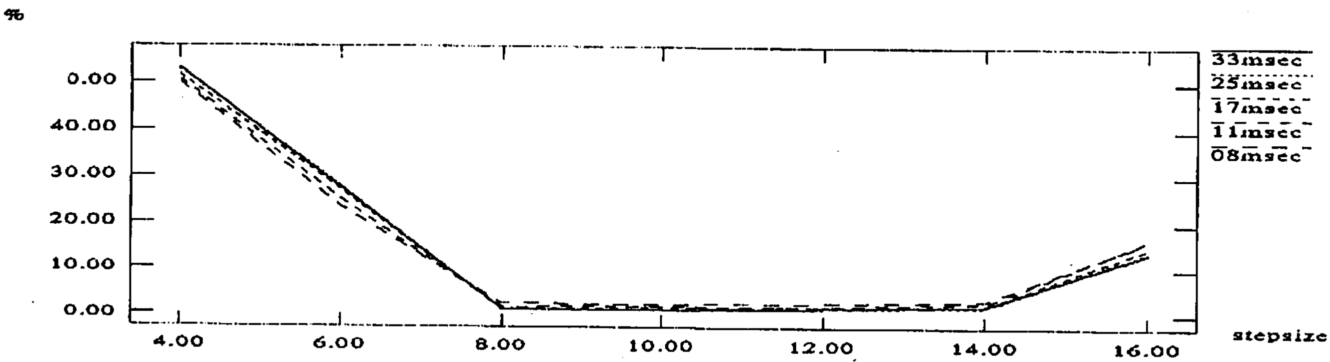


(d) 11.1mSec timeout

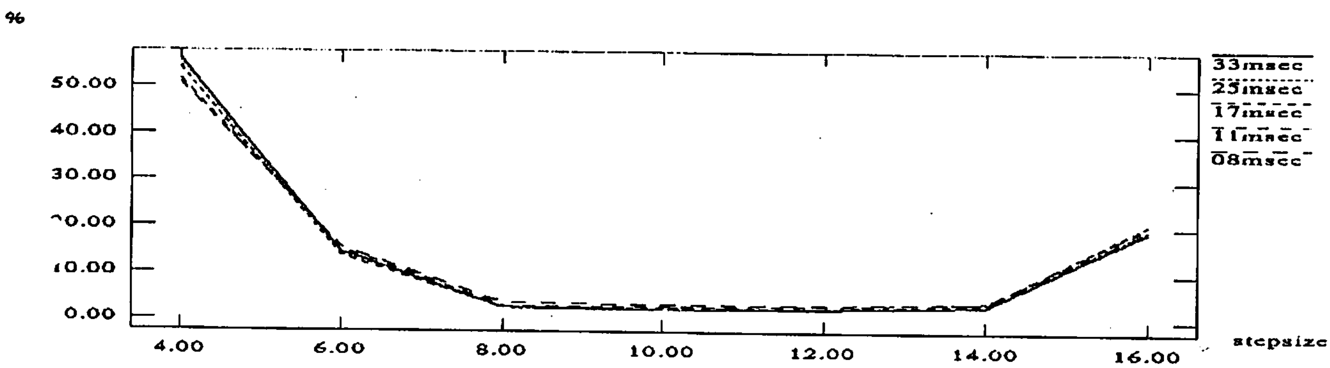
Figure 4: One second averaged bitrate, filled bitrate and leaky bucket transition for 3mSec maximum peak duration.



(a) Maximum peak duration : 29mSec



(b) Maximum peak duration : 3mSec



(c) Maximum peak duration : 0.3mSec

Figure 5: Average quantizer stepsize for timeout flush operation.