MPEG91/334

AVC-41と同じ

CCITT SGXV
Working Party XV/1
Experts Group for ATM Video Coding

Document AVC- 140
November 20, 1991

SOURCE: B, F, FRG, GR, I, NL, S, UK
TITLE: Statistical Multiplexing gains for variable Bit Rate
PURPOSE: Information, DSM meeting

1 Introduction

In this contribution, major parameters impacting on the statistical multiplexing gain (SMG) for VBR video codecs are identified. Also a minimum boundary for the SMG is derived.

The figures presented in this contribution are based on the measurements presented in the FRG SGXVIII contribution: Matsuyama, 26/11-12/91, Document D.962 [1].

Following definition is used in this contribution for Statistical Multiplexing Gain (SMG):

SMG = #VBR / #CBR,

where #VBR and #CBR indicate the number of VBR coded resp. CBR coded sources that can be multiplexed on a given ATM link, for a given, identical quality level of both VBR and CBR codec.

2 Minimum boundary for SMG.

In the past, a lot of attention was devoted to 'open loop' VBR video codecs, i.e. FBR codecs where the feedback loop has been cut. Such codecs show a higher peak bit rate with open loop than in fixed bit rate mode.
When comparing VBR vs. CBR codecs at *identical quality levels*, the peak bit rate however need not to be higher than the fixed bit rate (fig.1). Indeed, VBR operation reduces the bit rate below the fixed bit rate when possible, but the peak bit rate can be maintained at the level of the fixed bit rate, as for the comparison, the picture quality may be maintained at the same level, during the peak. The VBR graph is thus a sort of 'eroded' CBR graph (fig.1).

This leads to following equation:

VBRmean < VBRpeak = CBR. (1)

If this condition is included in the call acceptance and bandwidth allocation formula's of an ATM network, it is clear that the bandwidth allocated for a VBR coded source is smaller or equal to the CBR equivalent.

??
CBRが dummy bit を送っている状況では?

Statistical Multiplexing Gains are thus always larger or equal to 1.

3 Parameters impacting Statistical Multiplexing Gains

[1] gave figures on SMGs for different type of applications and sources. In fig. 2, these SMGs are plotted in function of SD/Mean, for a constant number of multiplexed sources (40). For the calculation of this graph, the network model described in [2] is used, which is based on a Gaussian 'gabarith'.
The figure shows that the SMG is approximately proportional with SD/mean. The higher the relative bit rate fluctuations, the higher the SMG becomes. In the fixed bit rate limit (SD=0), SMG becomes 1.

This is in line with the erosion model of fig. 1: with increasing erosion, the standard deviation increases, and the mean decreases. The bandwidth usage is thus reduced, giving larger SMGs.

Following parameters impact on the SD/Mean ratio, and thus on the SMG:

1. *Codec* adaptability*:* The better the adaptability of a codec to the scene content, the deeper the erosion becomes. Codecs using intra/interframe prediction switching, criticality adaptation, etc. are well suited for VBR operation. On the other hand, PCM codecs show no adaptability and thus no SMG.

2. *Noise in sources:* Noise represents a constant information content and disturbs the adaptability of a video codec to the image contents. In the limit, very noisy sources generate a fixed bit rate (sd/mean~0), with a SMG converging to 1.

3. *Source bit rate:* The lower the bit rate, the more sources that can be multiplexed on a given link rate. Fig. 3 gives the SMG in function of equivalent load over available link rate. The equivalent load (EL) is defined as the total link rate (LR) divided by the number of VBR channels.

4. *Link bit rate:* the higher the bit rate on the link, not occupied by CBR services, the higher the SMG, cfr. fig. 3.

5. *Change in image contents:* Videophone scenes with alternate sequences of listening and talking generate a large variation in bit rate. Also, TV programs may generate large variations in bit rate: eg. snooker program followed by football program.

6. *Integration period.* If source statistics are only measured over a short period, possibility exist that only periods of relative constant bit rate are covered. E.g. for TV-distribution, a

measurement over a football program does not provide a mean value that is valid over other programs. Attention must be paid when interpreting measurements over short intervals.

4 VBR vs. FBR

[1] showed that under good conditions high SMGs are achievable. Both video codec and network benefit from the enhanced efficiency. It is important to notice that for CBR coding, achieving similar bandwidth reductions in the codec itself, without quality loss, is not trivial, and represent a high complexity penalty in the terminals.

For some particular conditions, discussed above , SMGs reduce to 1. In that case, a VBR codec may prefer to operate in CBR mode, as it sees no advantages (same bandwidth allocated). CBR operation is a specific case of VBR operation, and therefore compatibility between both modes is easily achievable.

5 Conclusions

Statistical multiplexing gains are always larger or equal to 1, if proper (closed loop) coding and bandwidth allocation algorithms are used.

A series of parameters influencing statistical multiplexing gains have been given.

Under good conditions, bandwidth efficiencies are achieved, that are difficult to obtain with standard CBR video compression techniques. In some particular cases, compatible CBR mode may be preferred.

There is no need to make a generic choice between CBR and VBR: both modes can be compatible, and a choice can be made for each individual application.

6 References

[1] FRG, SGXVIII Matsuyama, 26/11-12/91, Document D.962

[2] Verbiest W., Pinnoo L., Voeten B., "The impact of the ATM concept on video coding", IEEE JSAC on Broadband Packet Communications, December 1988, pp. 1623-1632.

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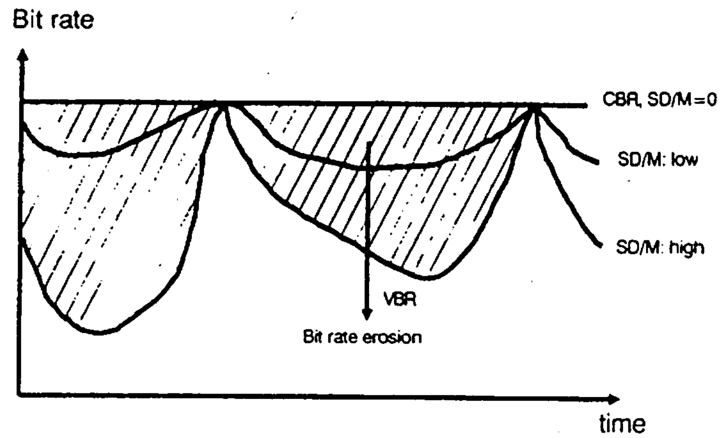

Figure 1: VBR as an erosion of CBR

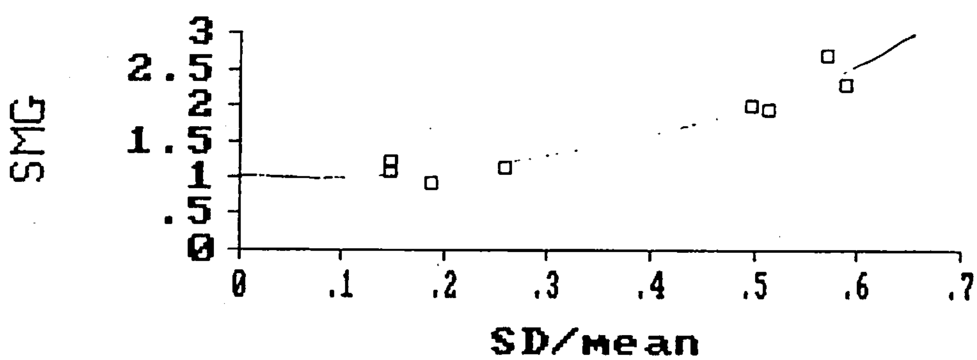

Figure 2: SMG vs. SD/Mean

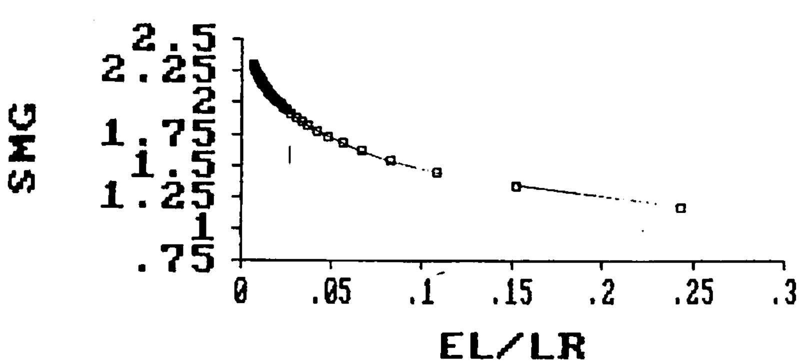

Figure 3: SMG vs. EL/LR