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

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Subject: Clock Recovery For Video

Source: Bellcore

Purpose: Discussion

1. Introduction

Synchronous Residual Time Stamp (SRTS) was accepted in CCITT SG XVIII as the timing recovery method for constant bit rate services. This contribution examines the possibility of using SRTS for clock recovery in video applications for both CBR and VBR connections.

2. Synchronous Residue Time Stamp

The essence of SRTS is to use a common clock (usually derived from the network) that is available at both the transmitter and the receiver. The asynchronous service clock is compared to the common reference clock, the difference in frequency is measured, and conveyed to the receiver in the form of a Residual Time Stamp (RTS). The RTS represents the number of reference clock cycles (modulo 16) that occurs in a period defined by a fixed number (3008 for circuit emulation) of service clock cycles. It is carried in the SAR overhead using the CSI bit and has a capacity of 4 bits every 8 cells in type I AAL.

When dealing with the timing recovery for video applications, the timing of interest is the recovery of the transmitter's video sampling clock at the receiver. The video clock is in general not related to the video data rate. This is true for both CBR and VBR encoded video. Thus, when SRTS is applied to video, the video sampling clock (or submultiples of it) should be the service clock.

3. Timing Recovery For CBR Video Services

For the transport of audiovisual services at the rates of px64 kbit/s on ISDN, the pictures are sampled at an integer multiple of the video line rate, which is in general asynchronous to the ISDN timing. Also, since frame dropping is used in H.261, no timing recovery at the receiver is needed. As shown in Figure 1, the output of the video coder has variable bit rate. This variable rate bit stream is smoothed by a buffer. The READ clock of the buffer comes from the ISDN. Feedback from the buffer to the video coder is used to control the data rate and prevent buffer overflow. At the receiver (not shown), a local clock is used for the generation of the video sampling clock. Since the local clock is in general asynchronous to the source video sampling clock, a frame slip buffer is used for synchronization.

There may be applications where timing recovery is desired for transporting H.26X video services over the ATM network [2]. Two scenarios regarding the timing source for the constant video data output clock (f_{CBR}) can be identified. The first case is similar to that of the H.261, in which f_{CBR} is generated from the ATM network clock and is thus asynchronous to the video sampling clock. In this case, the SRTS method can be applied to f_{sm}, a submultiple of the video sampling clock (f_s) as shown in Figure 2. A submultiple of the sampling clock needs to be used because the video sampling clock frequency is usually much higher than the video CBR service rate. For example, for a H.261 CIF, the sampling rate is about 3.1 MHz (360 pixels x 288 lines x 30 frames/sec), and if p=10, the video output rate is only 640 kb/s. According to [1], the source clock frequency (f_{source}) should satisfy the following:

$$\frac{f_{nx}}{2} < f_{source} \le f_{nx} \quad (1)$$

where f_{nx} is derived from the network clock.

Therefore, if SRTS is to be used directly, a suitable submultiple (e.g. 8) of the sampling clock should be used in this example.

In the second case, f_{CBR} is locked to the video sampling clock. Thus SRTS can be directly applied to f_{CBR} as shown in Figure 3. This is analogous to circuit emulation and SRTS can be used with no change because f_{CBR} carries the video sampling clock information.

4. SRTS For VBR Video Services

For VBR video services, the video output data rate varies within bounds according to the parameters determined during call setup and is continuously policed at the UPC (User Parameter Control) which is located at the first network entrance point. Because the video rate is variable, there is no equivalent of f_{CBR}. An analogous function is the Rate Control function, whose function is to monitor and control the video output rate in order not to violate the service contract. However, SRTS can still be used since the relevant timing information is f_s, the sampling clock or f_{sm}, its submultiples. Referring to Figure 4, a rate control box is needed to satisfy the rate requirement of the chosen service. In this case, SRTS can be applied to f_s. However, some modification of the RTS channel is needed. For circuit emulation using type I AAL, 4 bits in every 8 cells are allocated for the RTS. In VBR video application, this fixed RTS channel as defined in type I needs to be modified for two reasons.

First, since the video output rate is variable, the corresponding RTS channel also has variable rate. The limiting situation occurs during periods when compression is maximum. Such periods are characterized by the property that they require an unusually long time, i.e. a large number of video clocks to generate sufficient compressed output data to fill eight cells. One way to ensure this is to make the RTS period (T) large enough so that the RTS capacity is larger than 4 bits/8 cells, thus we have,

$$T \times f_{VBR}(min) \ge 3008 \quad (2)$$

where $f_{VBR}(min)$ is the minimum video data rate.

If T is chosen to be a video frame (33 msec), $f_{VBR}(min)$ should be over 90 kb/s. For a 3 Mbit/s video service, this represents about 3% of the average. If this requirement is not satisfied, we can either increase T or use a buffer to store the RTS temporarily. It should be noted that such buffering of the RTS will not increase the delay of the video signal.

Second, again due to the variable rate of the RTS channel, a signaling mechanism is needed to indicate the occurrence of the RTS. Exact representation of the RTS is for further study and since this involves the definition of type II AAL, it is best done in collaboration with SG XVIII.

5. Conclusion

This contribution examines the use of SRTS, which is defined for type I AAL for CBR service, in video applications. Both CBR and VBR video applications are examined. For CBR applications, SRTS can be applied with no modifications. For VBR video services, a modification of the RTS channel is necessary. Exact specification of the RTS channel for VBR video services is for further study and is preferably done with the collaboration of SG XVIII.

6. Reference

[1] CCITT SG XVIII, "Synchronous Residue-Time Stamp: A Combination of SFET/TS," US contribution, December 1991.

[2] CCITT SG XV, AVC-121, "Video Clock Justification," Japan contribution, November, 1991.

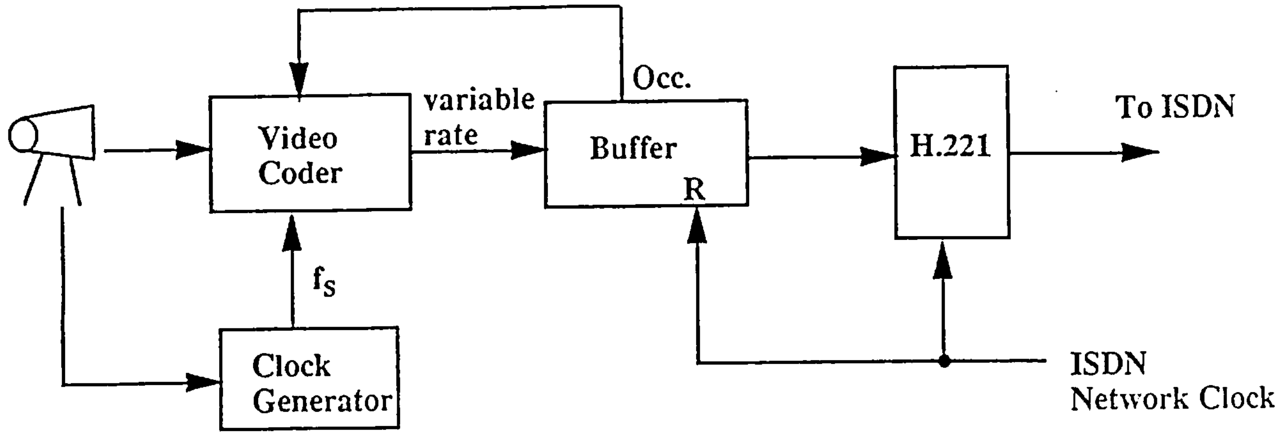

Figure 1 : H.261 on ISDN (No timing recovery)

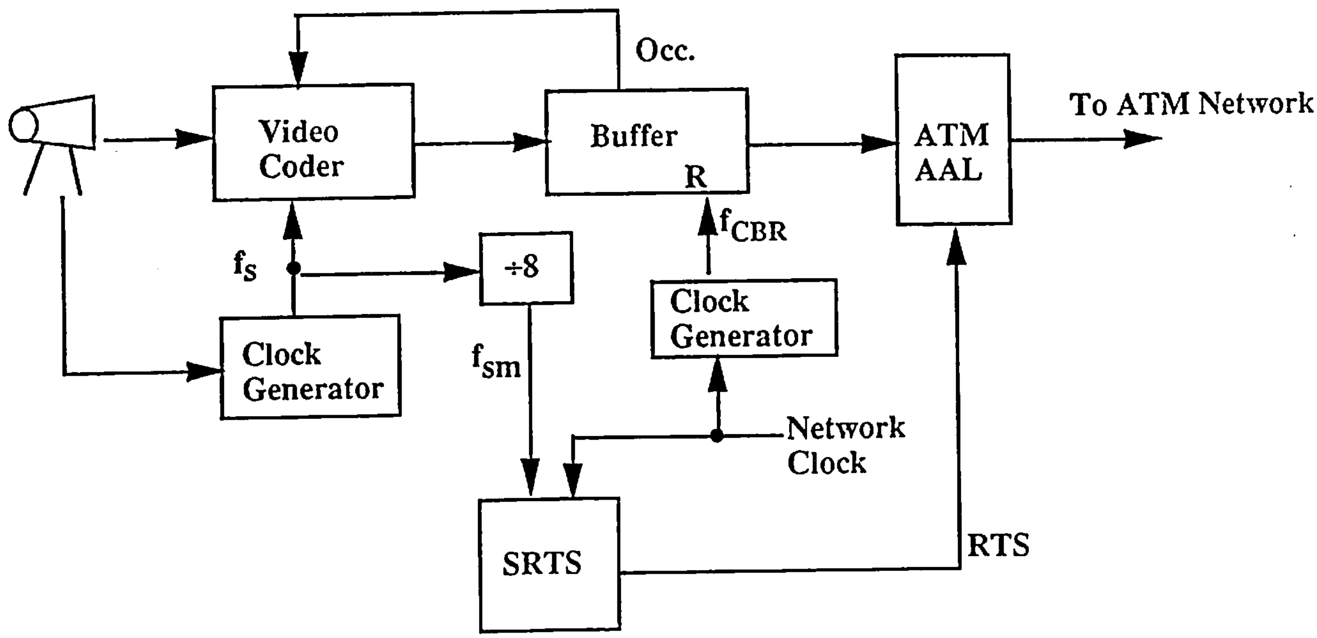

Figure 2 : SRTS For CBR Video (f_{CBR} asychronous to f_s)

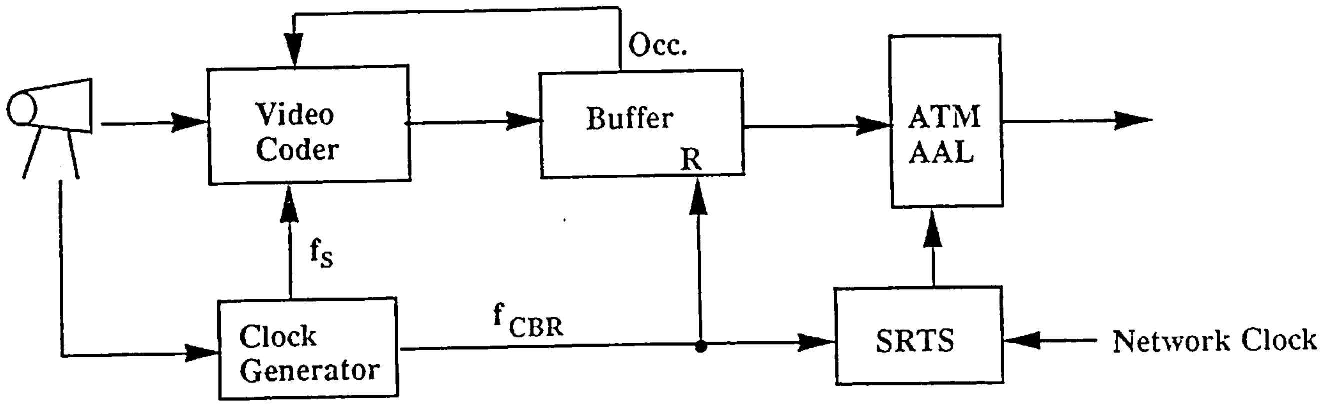

Figure 3 : SRTS For CBR Video (f_{CBR} locked to f_S)

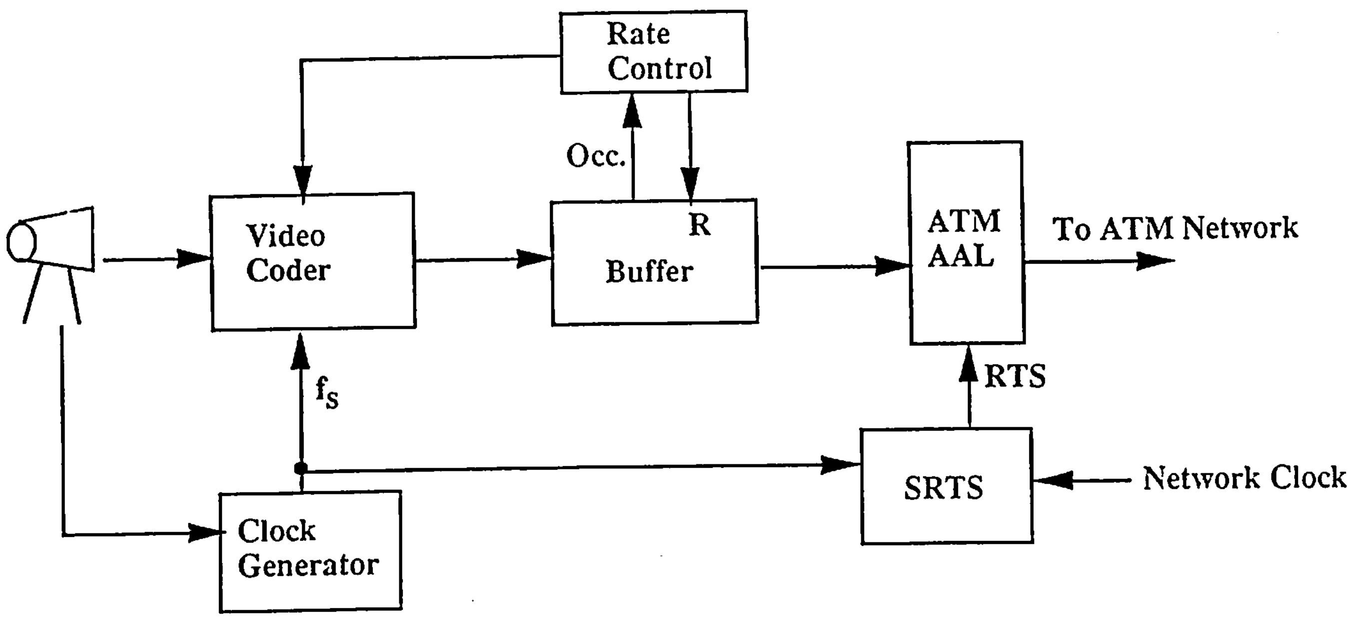

Figure 4 : SRTS For VBR Video