CCITT SGXV
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Specialists Group on Coding
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Title: IDEAS ON DELAY MEASUREMENT

It is likely that experts on H.261 will have to give advice in the future on how to measure video coding delay. This document gives some input to the discussion on the topic.

Our opinion is that delay must be treated from a users point of view, i.e. the measured figure must reflect the delay which occurs during normal use of the equipment.

First of all, delay must be well defined. We propose the following definition of "overall delay".

Overall Delay.
The overall delay is defined as the time difference between picture sync in camera and first picture sync in monitor. (t12-t1 in Figure 1)

The basic contributions to the overall delay are illustrated in Figure 1.

When a specific service is defined it may be necessary to put restrictions on the delay produced by H.261 machines used in the service. Such restrictions may imply that the "freedom" as specified in H.261 can not be completely used in the codec. Examples of such reduced freedoms could be put on frame rate, number of bits per picture anf buffer size.

As encoders and decoders from different manufacturers can be used, it is necessary to put independent delay restrictions on them. It is reasonable to split up the overall delay as follows:

Encoder delay	+	Transmission delay	+	Decoder delay	=	Overall delay

From an H.261 point of view the Transmission delay can be ignored, and set to zero. What we have to do is to define methods to measure Encoder delay and Decoder delay.

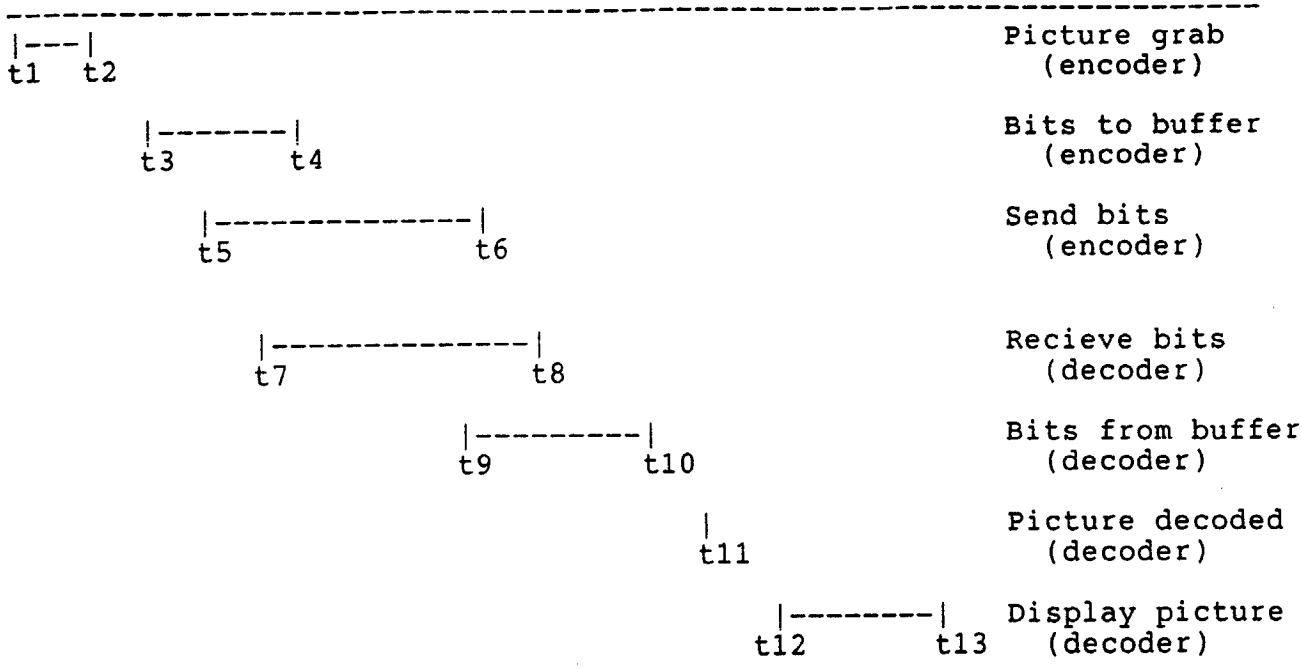

Figure 1. Illustration of contributions to delay.

t1 Picture sync in encoder camera.
t3 First bit put into transmission buffer.
t5 First bit sent out.
t6 Last bit sent out.

t2-t1 20 ms in PAL countries.
t3-t1 Encoder processing delay.
t4-t3 Encoder processing speed.
t5-t3 Depends on encoder history.
t6-t5 Depends on number of bits for the picture.

t7-t5 (=t8-t6) Transmission delay, for example satellites.

t7 First bit recived in decoder.
t8 Last bit recieved in decoder.
t9 First bit read from buffer.
t10 Last bit read from buffer.
t11 Picture decoded.
t12 First sync in decoder monitor.

t9-t7 Depends on decoder strategy and history.
t10-t9 Decoder processing speed (provided t10>t8).
t11-t10 Decoder processing delay.
t12-t11 Wait for monitor sync.
t13-t12 Display time in decoder.

Encoder discussion.

The encoder situation is relatively simple, as it is alone responsible for its own situation. In fact it is completely responsible for everything up to the time t6.
Therefore, it is reasonable to define Encoder delay as t6-t1.
A practical problem in a measurement may be to identify the Picture Start Code in the bit stream (t6) which corresponds to a specific camera sync (t1). We believe this problem has a solution.

Decoder discussion.

A reasonable definition of decoder delay is t12-t8.
However, the decoder situation is more complicated than for the encoder. One reson is that the decoder delay may depend on encoder behaviour.
One such case is when the encoder uses very few bits (corresponding to much less than k/29.97 s) for some pictures. The decoding time is k/29.97 s for each of these pictures, and thus some pictures will have to wait.
We can see two possibilities to come around this problem.

A. Measure decoder delay (t12-t8) at a well defined situation. For example, "reference encoder" and specific picture material.

B. Ignore the part of the delay which is out of the decoder control. For example, Decoder delay = t12-t10.

The problem with method A is to define the "reference encoder" and the picture material.
The problem with method B is that overall delay is not measured. If the decoder always operates with many bits in the buffer (t10-t8 is always large), even when not necessary, this is controlled by the decoder and should be reflected by in the measured figure.
A further problem is that the decoder can be "cheating", i.e. designed such that the last bit (t10) is picked very late, with the only aim to produce a short measured delay.

Our opinion is that method B is not acceptable, and that the goal should be to overcome the problems with method A.

Human factor aspects.

It is important that delay measurements are done such that the resulting figures reflect the overall delay under normal operating conditions = reasonably moving pictures.
Therefore, the achieved figures should be long term average values and standard deviations. Special figures can also be measured for extreme cases, such as scene cuts.

Conclusions.

Encoder delay = t6 - t1.
Decoder delay = t12 - t8.
Exact conditions for measurements have to be defined.