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SERIES J: CABLE NETWORKS AND TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Miscellaneous

Seamless splicing for MPEG-2 bit streams

ITU-T Recommendation J.189

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ITU-T Recommendation J.189

Seamless splicing for MPEG-2 bit streams

Summary

This Recommendation specifies an MPEG-2 bit-stream syntax for transport stream splicing and a transport mechanism of scheduling information for splicing devices to enable seamless splicing for digital program insertion, which means that different program signals are switched at an appointed time to produce complete TV programs or to insert local advertisements and emergency messages into the TV program signals.

Source

ITU-T Recommendation J.189 was prepared by ITU-T Study Group 9 (2001-2004) and approved under the WTSA Resolution 1 procedure on 29 July 2002.

FOREWORD

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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ITU-T Recommendation J.189

Seamless splicing for MPEG-2 bit streams

1 Scope

The processing of the MPEG-2 bit stream is becoming increasingly necessary in a TV transmission chain to avoid picture quality degradation due to multiple cascaded MPEG-2 encoding and decoding. In fact, local television operators normally receive several TV program signals from different or remote sources in the form of MPEG-2 bit streams. They switch these program signals at an appointed time to produce complete TV program signals, or they insert local advertisements and emergency messages into the TV program signals. In these switching, seamless bit-stream insertions, splicing has been strongly demanded to avoid picture quality degradation on the splicing point at the decoder side. For MPEG-2 bit-stream splicing, two techniques have been recommended in ITU-T Recs H.222.0 | ISO/IEC 13818-1 and J.181. An MPEG-2 syntax of a spliceable bit stream recommended in ITU-T Rec. H.222.0 | ISO/IEC 13818-1 means a PID stream whose discontinuity in a time-stamp or a time base can be processed seamlessly by the MPEG-2 bit stream splicing device. These syntaxes are defined as splicing point flag, seamless splice flag, splice type and so forth. The transport mechanism of scheduling information on a splicing event for splicing devices is also recommended in ITU-T Rec. J.181.

This Recommendation specifies a seamless splicing technique for the MPEG-2 bit stream based on the two existing Recommendations above. The MPEG-2 syntax of a spliceable bit stream is fully in accordance with ITU-T Rec. H.222.0 | ISO/IEC 13818-1, while the transport mechanism of scheduling information is modified by applying some constraints on the streams being spliced.

"Seamless splicing" here means switching from one MPEG-2 video elementary stream to a second elementary stream supplied to a single decoder such that:

- continuity of the spliced bit stream is maintained;
- no underflow or overflow of the decoder buffer occurs as a result of the splice;
- no visible artifacts in the reconstructed baseband video are introduced.

In addition, other types of splicing schemes without any splicing information are given in the appendices as reference information.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

2.1 Normative references

– ITU-T Recommendation H.222.0 (2000) | ISO/IEC 13818-1:2000, *Information technology – Generic coding of moving pictures and associated audio information: Systems*.

– ITU-T Recommendation H.262 (2000) | ISO/IEC 13818-2:2000, *Information technology – Generic coding of moving pictures and associated audio information: Video*.

– ITU-T Recommendation J.181 (2001), *Digital program insertion cueing message for cable television systems*.

2.2 Informative references

– SMPTE 312M-2001, *Television – Splice Points for MPEG-2 Transport Streams*.

3 Terms, definitions and acronyms

This Recommendation defines the following terms:

3.1 access unit: The coded representation of a video or an audio frame (see ITU-T Rec. H.262 | ISO/IEC 13818-2).

3.2 bit stream: MPEG-2 transport stream defined in ITU-T Rec. H.222.0 | ISO/IEC 13818-1.

3.3 in point: A point in the bit stream, suitable for entry, that lies on an elementary access unit boundary.

3.4 in point packet: A transport stream packet which corresponds to the first packet following the In Point.

3.5 out point: A point in the bit stream, suitable for exit, that lies on an elementary access unit boundary.

3.6 out point packet: A transport stream packet which corresponds to the last packet prior to the Out Point.

3.7 PID stream: All the packets with the same PID within a transport stream.

3.8 presentation time-stamp (PTS): A field that may be present in a PES packet header that indicates the time that a presentation unit is presented in the system target decoder.

3.9 presentation unit (PU): A decoded audio access unit or a decoded picture (see ITU-T Rec. H.262 | ISO/IEC 13818-2).

3.10 program in point: A group of PID stream In Points that correspond in presentation time.

3.11 program out point: A group of PID stream Out Points that correspond in presentation time.

3.12 program splice point: A Program In Point or a Program Out Point.

3.13 splice point: A point in a PID stream that is either an Out Point or an In Point.

3.14 spliceable stream: A PID stream whose discontinuity in a time-stamp or a time base can be processed seamlessly by the MPEG-2 bit stream splicing device. The basic syntax is defined in ITU-T Rec. H.222.0 | ISO/IEC 13818-1.

3.15 splice time: A presentation time of the intended splice point, which is equivalent to the presentation time of the access unit following the intended splice point.

4 MPEG-2 bit-stream insertion techniques

4.1 Configuration

The basic syntax of a spliceable bit stream is recommended in ITU-T Rec. H.222.0 | ISO/IEC 13818-1. A spliceable bit stream means a PID stream whose discontinuity in a time-stamp or a time base can be processed seamlessly by the MPEG-2 bit stream splicing device. This mechanism is not sufficient for achieving a reliable splicing operation because of the following reasons:

– Splicing devices cannot obtain any preceding information indicating the time schedule with regard to upcoming splice points where a seamless program insertion is ensured.

– In the case of a program insertion, synchronization of all PID streams, which constitute the program, cannot necessarily be established.

Figure 1 shows the configuration of the splicing technique for the MPEG-2 bit stream assumed in this Recommendation. The transport mechanism of scheduling information is based on ITU-T Rec. J.181 with additional constraints required for the seamless splicing. This Recommendation defines additional constraints on bit-stream splice points for ITU-T Rec. J.181 and the desirable operation of the splicing device, which are required to achieve the seamless splicing.

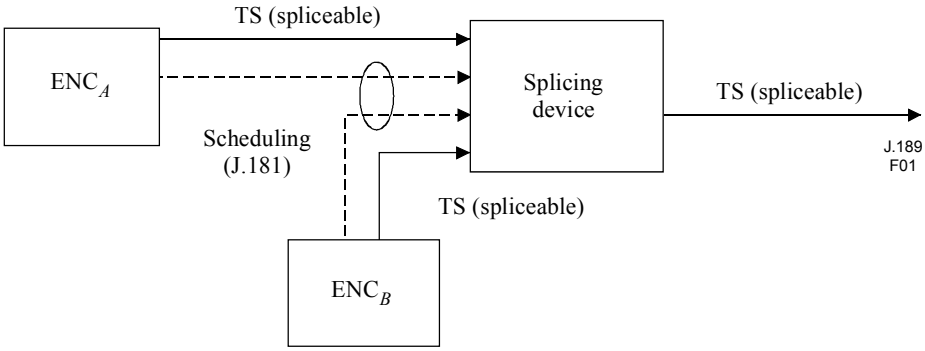


Figure 1/J.189 – Configuration of seamless splicing technique for the MPEG-2 bit stream

4.2 MPEG-2 bit-stream syntax required for seamless splicing

Those basic fields constituting a spliceable bit stream are defined as splicing_point_flag, splice_countdown, seamless_splice_flag, splice_type and DTS_next_AU in ITU-T Rec. H.222.0 | ISO/IEC 13818-1. These fields are mapped into an adaptation field of transport stream packets as shown in Figure 2, and the definition of each field is summarized thereafter.

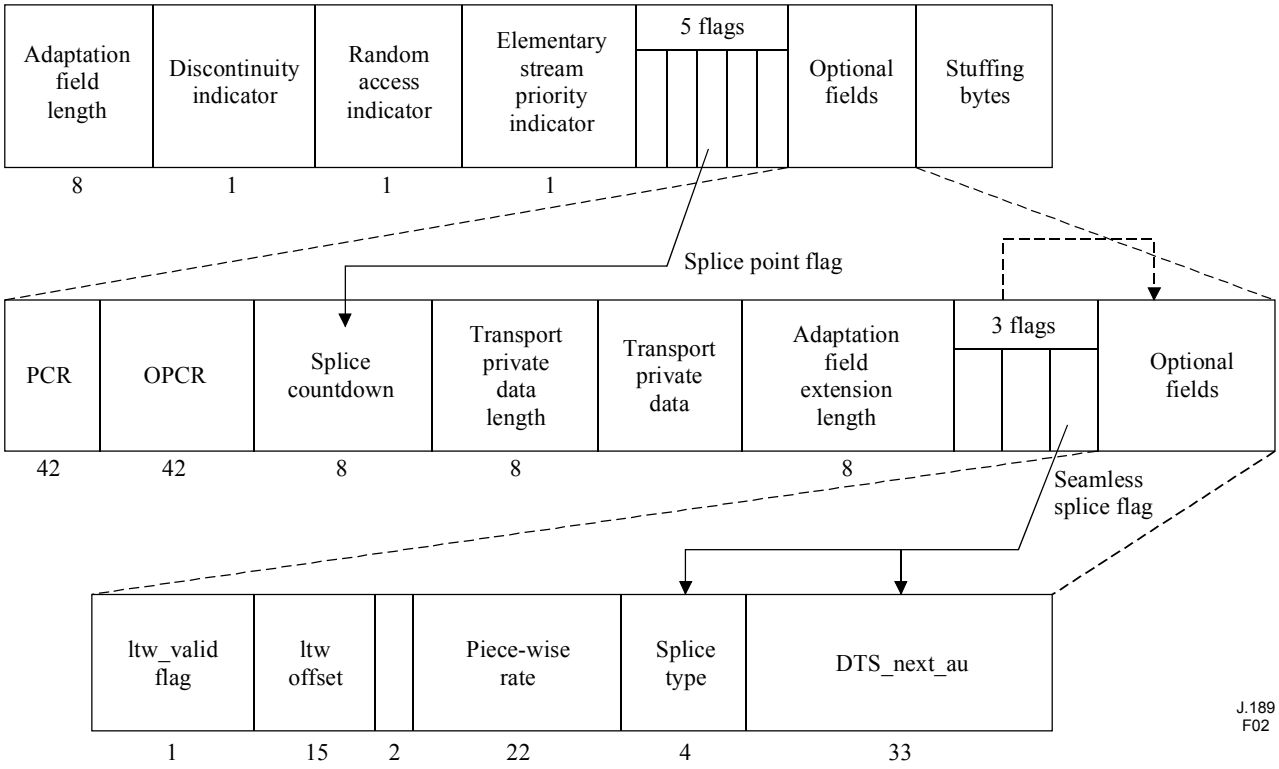


Figure 2/J.189 – Syntax of the adaptation field in the MPEG-2 transport stream packet

– splicing_point_flag: When set to "1", this field indicates the presence of the splice_countdown field, specifying the occurrence of a splicing point.

– splice_countdown: A positive value specifies the remaining number of transport stream packets, of the same PID, following the associated transport stream packet until a splice point is reached. The transport stream packet in which the splice_countdown field reaches zero corresponds to the Out Point packet. A negative value specifies that the associated transport stream packet is the packet following the splicing point.

– seamless_splice_flag: When set to "1", it indicates the presence of the splice_type and DTS_next_AU fields.

– splice_type: This field indicates the condition that shall be respected by an associated elementary stream for splicing purposes especially for video PID streams.

– DTS_next_AU: This field indicates the decoding time of the first access unit following the splicing point, where the decoding time is expressed in the time base, which is valid in the transport stream packet in which the splice_countdown reaches zero.

When the bit stream is assumed to be a spliceable one as described above, seamless splicing is basically enabled based on simple bit-stream switching as shown in Figure 3, using an appropriate splicer equipment. Bit-stream splicing is applied directly to bit streams where possible splice points must be provided by the upstream encoder. In addition, the upstream encoder must control the number of encoded bits to put the downstream decoder in a stable buffer state at each Out Point, otherwise seamless switching can not be realized. The splicing device based on this approach can be implemented without any re-encoding processing. Other splicing approaches which do not require any constraints on bit-stream splice points are described in the appendices.

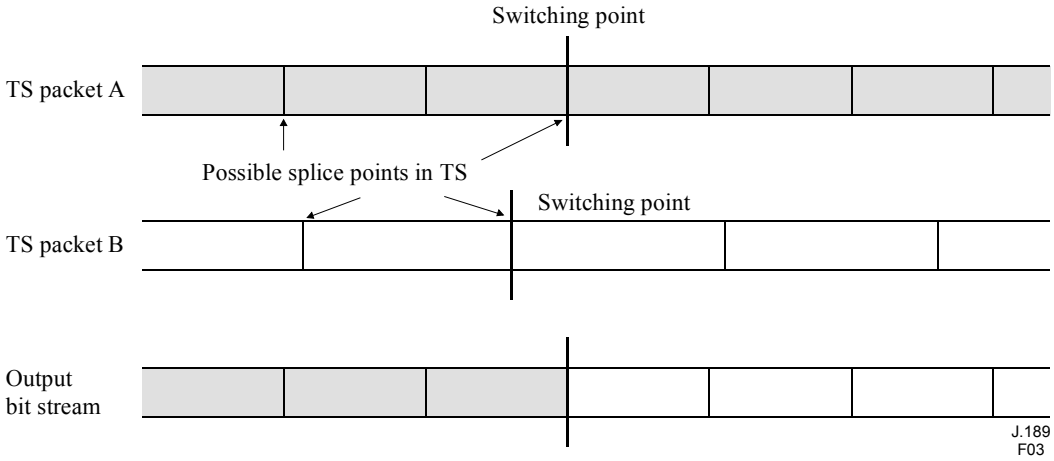


Figure 3/J.189 – Bit-stream splicing

4.3 Transport mechanism of scheduling information for splicing devices

4.3.1 Basic mechanism based on ITU-T Rec. J.181

Detailed information on a splicing event (the possible splice point, the PID of the spliced stream, the schedule of upcoming splicing events, etc.) can be mapped into a bit stream as the splice information section specified in ITU-T Rec. J.181. The splice information section notifies the splicing device of scheduled splice events prior to the arrival of splice points, and enables the splicing device to ensure a reliable splicing operation. The splice information section shall be carried in transport stream packets within their own PID streams. Table 1 shows the syntax of the splice information section.

Table 1/J.189 – Syntax of the splice information section defined in ITU-T Rec. J.181

Syntax	Bits	Mnemonic	Encrypted
splice_info_section () {			
table_id	**8**	**uimsbf**	
section_syntax_indicator	**1**	**bslbf**	
private_indicator	**1**	**bslbf**	
reserved	**2**	**bslbf**	
section_length	**12**	**uimsbf**	
protocol_version	**8**	**uimsbf**	
encrypted_packet	**1**	**bslbf**	
encryption_algorithm	**6**	**uimsbf**	
pts_adjustment	**33**	**uimsbf**	
cw_index	**8**	**uimsbf**	
reserved	**24**	**bslbf**	
splice_command_type	**8**	**uimsbf**	**E**
if (splice_command_type=0x00)			
splice_null ()			**E**
if (splice_command_type=0x04)			
splice_schedule ()			**E**
if (splice_command_type=0x05)			
splice_insert ()			**E**
descriptor_loop_length	**16**	**uimsbf**	**E**
for (I=0; I<N; I++)			
splice_descriptor ()			**E**
for (I=0; I<N; I++)			
alignment_stuffing	**8**	**bslbf**	**E**
if (encrypted_packet)			
E_CRC_32	**32**	**rpchof**	**E**
CRC_32	**32**	**rpchof**	
}			

4.3.2 Constraints for seamless splicing

When applying J.181 as the splice information section, the Out Point and the In Point shall meet the following constraints in order to achieve seamless splicing. For video PID streams, seamless splicing between a low-delay sequence and a sequence containing at least one B-picture is not aimed at in this Recommendation.

4.3.2.1 Out Point constraints

4.3.2.1.1 For all PID streams

- The splicing_point_flag shall be set to 1 in the Out Point packet.
- The splice_countdown shall be set to 0(0x00) in the Out Point packet.
- The last byte of the Out Point packet payload shall be the last byte of a PES packet.
- The STC of a previous time base shall be established with sufficient precision until the time when the previous STC reaches the splice_time.

- Packets containing a PU with a PTS expressed in the new time base shall not arrive prior to receiving the first PCR packet of the new time base which accompanies the occurrence of time-base discontinuity.

4.3.2.1.2 For video or audio PID streams

- The seamless_splice_flag shall be set to 1 in the Out Point packet.
- DTS_next_AU shall be set in the Out Point packet, according to the definition in ITU-T Rec. H.222.0 | ISO/IEC 13818-1.
- The Out Point packet shall carry the splice_type field.
- For video PID streams, the value of the splice_type shall be selected from the table defined in ITU-T Rec. H.222.0 | ISO/IEC 13818-1. For audio PID streams, the value of the splice_type shall be set to "0000".
- For video PID streams, the last picture (in presentation order) preceding an Out Point shall be either a P- or an I-picture. An Out Point shall not occur between the two fields of a coded frame.
- For audio PID streams, if audio is organized into frames, then the last byte of an Out Point packet shall be the last byte of an audio frame.

4.3.2.2 In Point constraints

4.3.2.2.1 For all PID streams

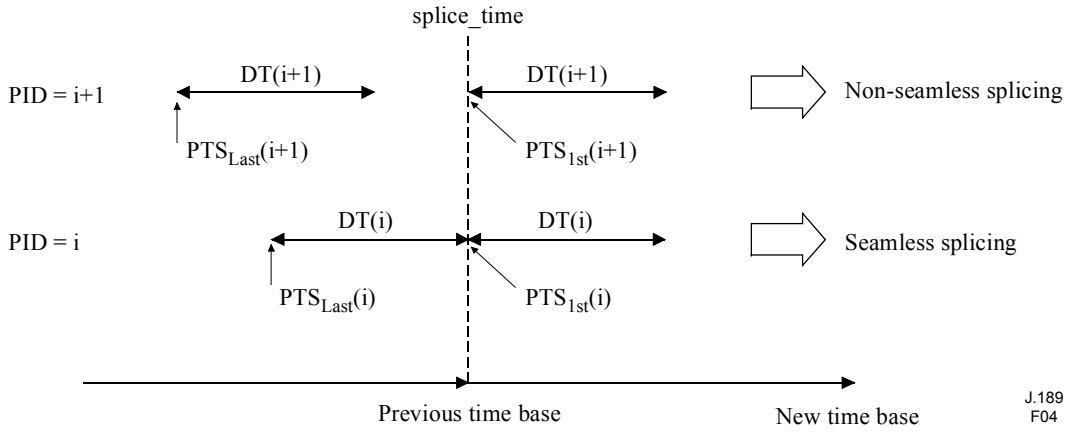
- The splicing_point_flag shall be set to 1 in the In Point packet.
- The splice_countdown shall be set to –1(0xFF) in the In Point packet.
- For PID streams, which contain a payload field, the payload_unit_start_indicator shall be set to 1 in the In Point packet.
- For PID streams, which contain a payload field, the first payload byte of the In Point packet shall be the first byte of a PES header, which shall carry a PTS. It shall carry a DTS if the DTS does not equal PTS.
- The STC of a new time base shall be established with sufficient precision in advance of the time when the previous STC reaches the splice_time.
- Packets containing a PU with a PTS expressed in the previous time base shall not arrive after receiving the first PCR packet of the new time base which accompanies the occurrence of time-base discontinuity.

4.3.2.2.2 For video or audio PID streams

- For video or audio PID streams, the data_alignment_indicator of the PES packet shall be set to 1.
- For video or audio PID streams, the random_access_indicator shall be set to 1 in the In Point packet.
- For video PID streams, the first PES packet payload following an In Point shall begin with a sequence header. Any P-picture or B-picture following an In Point shall not use a prediction which references pictures prior to the In Point. In the case of a progressive refresh coding structure being applied, the first coded picture after the sequence header shall be a P picture whose macroblocks are all intra coded.
- For audio PID streams, if audio is organized into frames, the first payload byte following an In Point shall be the first byte of an audio frame.
- For audio PID streams, data required for decoding the audio access units following the In Point shall not be contained in any audio frames prior to the In Point.

4.3.2.3 Program Splice Point constraints

Program In Points and Program Out Points are sets of PID stream In Points or Out Points, which correspond in presentation time. In a Program Splice Point, an elementary stream constituting a program does not necessarily guarantee a seamless splice, because the presentation units of all components are not necessarily aligned with each other. The case for achieving a seamless splice is shown in Figure 4. The elementary stream to be seamless should be designated at a splicing equipment.



PTS_{Last} PTS value obtained from the last PU of a PID stream before the splice_time
PTS_{1st} PTS value obtained from the first PU of a PID stream before the splice_time
DT Duration time for which the PU has been presented

Figure 4/J.189 – Constraints for seamless splicing at the Program Splice Point

4.3.2.3.1 Out Point constraints

For any PID stream, the following equation shall be satisfied, where PTS_{Last} is defined in Figure 3. In this equation, splice_time is expressed in the new time base.

$$splice\_time - DT < PTS_{Last} + DT \leq splice\_time$$

4.3.2.3.2 In Point constraints

For any PID stream, the following equation shall be satisfied, where PTS_{1st} is defined in Figure 3. In this equation, splice_time is expressed in the new time base.

$$splice\_time \leq PTS_{1st} < splice\_time + DT$$

Appendix I

Re-encoding with the side information approach

This approach is based on cascade coding where the MPEG-2 bit streams are decoded prior to processing and re-encoded afterwards. Although such a cascade coding approach allows any kind of processing with frame accuracy being realized, it is at the expense of significant picture quality loss.

The proposed re-encoding approach attempts to avoid such picture quality loss by using side information (e.g. motion vectors and coding mode decisions) decoded from the bit stream for the re-encoder. Figure I.1 shows a simple example of switching in this approach. The decoder is a

standard MPEG-2 decoder but with an additional side information output which is synchronized to the video output. The re-encoder is the core of an MPEG-2 encoder but makes all its coding decisions from the side information, thus ensuring that the re-encoder makes the same decision as that taken by the upstream coder.

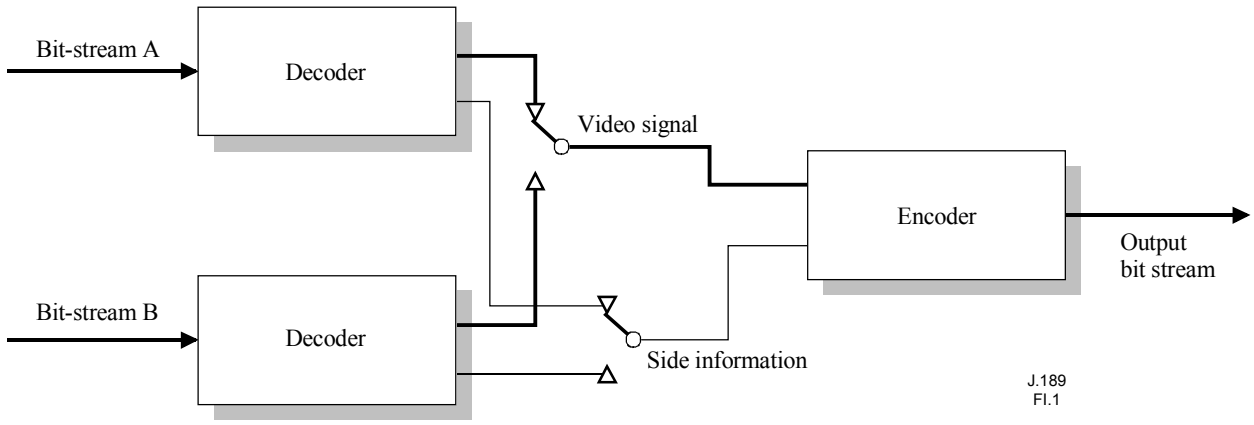


Figure I.1/J.189 – Re-encoding with the side information approach

In the steady state, when bit-stream A is selected, the side information is transferred to the re-encoder, so that the output bit stream is essentially identical to the source bit-stream A. This means there is no additional picture quality loss in the cascading. The same situation occurs in the steady state after the switching operation, when B is selected. Near the switching point, neither side information A or B is usable as the source of re-encoding decisions because the reference pictures to be used for the prediction are changed at the switching point. During the switching period the re-encoder works on its own decision, and cascading impairment is no longer eliminated during the period.

In addition, an additional recovery period is necessary during which the quantizer in the re-encoder is adjusted until the re-encoder buffer status is correctly related to the vbv delay value in the side information.

The advantage of this approach is flexibility, both in the choice of splice point and in the end of processing including transcoding. The extension of the approach to cross-fades and wipes is apparent. There is no restriction in MPEG-2 bit streams.

Appendix II

Partial re-encoding approach

This approach is based on a combination of bit-stream splicing and re-encoding. Figure II.1 shows a simple switching example of this approach. The re-encoder works only during the switching period.

In the steady state, when bit-stream A is selected, the bit stream itself becomes the output stream without re-encoding. Therefore, no additional picture quality loss is incurred. The same situation occurs in the steady state after a switching operation, when bit-stream B is selected. In principle, this approach is almost equivalent to re-encoding with side information in the steady state. Near the switching point, the re-encoder works for the selected video signals by its own coding decision. The advantage of this partial re-encoding approach is the same as that of re-encoding with side information. In addition, there is no need to install a spatial MPEG-2 decoder and encoder equipped with the side information output and input.

The specification of the re-encoder should be defined taking into account system simplification and picture quality loss in a transition period. For example, a re-encoder without a B-picture (bi-directional prediction picture) is suitable for low delay switching.

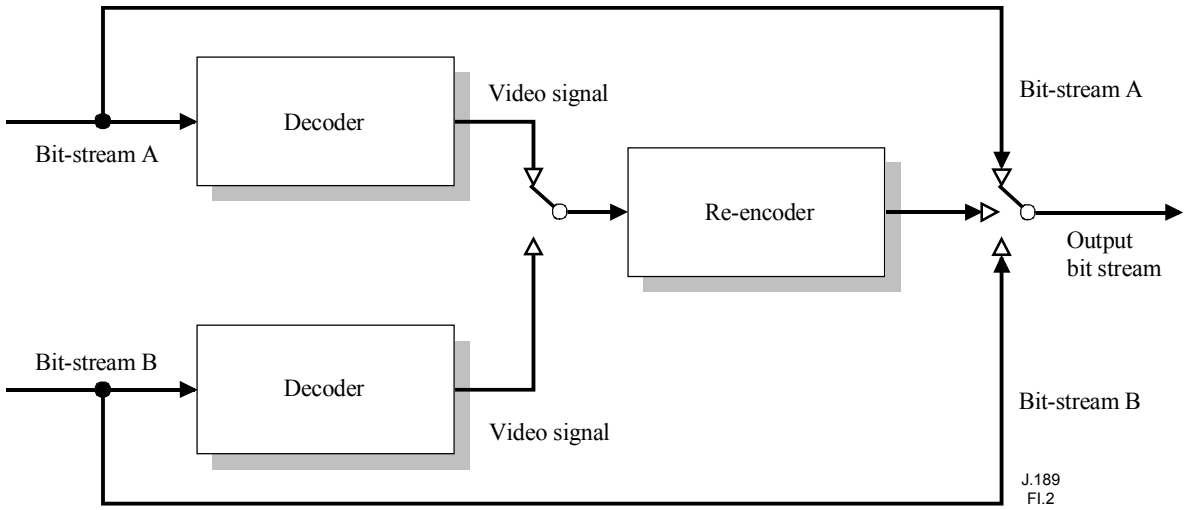


Figure II.1/J.189 – Partial re-encoding approach

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