TECHNICAL REPORT

# ISO/IEC TR 13818-5

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# Information technology — Generic coding of moving pictures and associated audio information —

## Part 5: Software simulation

*Technologies de l'information — Codage générique des images animées et des informations sonores associées —*

*Partie 5: Simulation de logiciel*

Reference number
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# Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/IEC 13818-5, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

This second edition cancels and replaces the first edition (ISO/IEC 13818-5:1997), which has been technically revised. It also incorporates the Amendments ISO/IEC TR 13818-5:1997/Amd.1:1999 and ISO/IEC TR 13818-5:1997/Amd.2:2005, and the Technical Corrigenda ISO/IEC TR 13818-5:1997/Amd.1:1999/Cor.1:2003 and ISO/IEC TR 13818-5:1997/Amd.1:1999/Cor.2:2004.

ISO/IEC 13818 consists of the following parts, under the general title *Information technology — Generic coding of moving pictures and associated audio information*:

— *Part 1: Systems*

— *Part 2: Video*

— *Part 3: Audio*

— *Part 4: Conformance testing*

— *Part 5: Software simulation* [Technical Report]


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— *Part 6: Extensions for DSM-CC*

— *Part 7: Advanced Audio Coding (AAC)*

— *Part 9: Extension for real time interface for systems decoders*

— *Part 10: Conformance extensions for Digital Storage Media Command and Control (DSM-CC)*

— *Part 11: IPMP on MPEG-2 systems*

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# Introduction

This Part of ISO/IEC 13818 was developed in response to the growing need for a generic coding method of moving pictures and of associated sound for various applications such as digital storage media, television broadcasting and communication. The use of this specification means that motion video can be manipulated as a form of computer data and can be stored on various storage media, transmitted and received over existing and future networks and distributed on existing and future broadcasting channels.

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document may involve the use of patents.

The ISO and IEC take no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the ISO and IEC that he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with the ISO and IEC. Information may be obtained from the companies listed in Annex B.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified in Annex B. ISO and IEC shall not be held responsible for identifying any or all such patent rights.


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# Information technology — Generic coding of moving pictures and associated audio information —

## Part 5:
## Software simulation

## 1 Scope

This Technical Report provides a C language software simulation of an encoder and decoder for Part 1 (Systems), Part 2 (Video), Part 3 (Audio), Part 7 (AAC) and Part 11 (IPMP) of ISO/IEC 13818.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 639 (all parts), *Code for the representation of names of languages*

ISO 8859-1, *Information processing - 8-bit single-byte coded graphic character sets - Part 1: Latin alphabet No. 1*

ISO/IEC 10918-1:1994, *Information technology - Digital compression and coding of continuous-tone still images: Requirements and guidelines* (See also ITU-T Rec. T.81.)

ISO/IEC 11172-1:1993, *Information technology - Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s - Part 1: Systems*

ISO/IEC 11172-2:1993, *Information technology - Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s - Part 2: Video*

ISO/IEC 11172-3:1993, *Information technology - Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s - Part 3: Audio*

ISO/IEC 11172-4:1995, *Information technology - Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s - Part 4: Compliance testing*

ISO/IEC 11172-5:1998, *Information technology - Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s - Part 5: Software simulation*

ISO/IEC 11172-6, *Information technology - Coding of moving pictures and associated audio for digital storage media at up to about 1,5 Mbit/s - Part 5: Specification for implementation of Inverse Discrete Cosine Transform*

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

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

ISO/IEC 13818-3:1998, *Information technology - Generic coding of moving pictures and associated audio information - Part 3: Audio*

ISO/IEC 13818-4:2004, *Information technology - Generic coding of moving pictures and associated audio information - Part 4: Conformance testing*

ISO/IEC 13818-7:2004, *Information technology – Generic coding of moving pictures and associated audio information - Part 7: Advanced Audio Coding (AAC)*

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ISO/IEC 13818-11:2004, *Information technology – Generic coding of moving pictures and associated audio information – Part 11: IPMP on MPEG-2 systems*

## 3 Terms and definitions

For the purposes of this document, the following definitions apply.

**3.1 16x8 prediction [video]:** A prediction mode similar to field-based prediction but where the predicted block size is 16x8 luminance samples.

**3.2 AC coefficient [video]:** Any DCT coefficient for which the frequency in one or both dimensions is non-zero.

**3.3 access unit [systems]:** A coded representation of a presentation unit. In the case of audio, an access unit is the coded representation of an audio frame.
In the case of video, an access unit includes all the coded data for a picture, and any stuffing that follows it, up to but not including the start of the next access unit. If a picture is not preceded by a group_start_code or a sequence_header_code, the access unit begins with the picture start code. If a picture is preceded by a group_start_code and/or a sequence_header_code, the access unit begins with the first byte of the first of these start codes. If it is the last picture preceding a sequence_end_code in the bitstream all bytes between the last byte of the coded picture and the sequence_end_code (including the sequence_end_code) belong to the access unit.

**3.4 adaptive bit allocation [audio]:** The assignment of bits to subbands in a time and frequency varying fashion according to a psychoacoustic model.

**3.5 adaptive multichannel prediction [audio]:** A method of multichannel data reduction exploiting statistical inter-channel dependencies.

**3.6 adaptive noise allocation [audio]:** The assignment of coding noise to frequency bands in a time and frequency varying fashion according to a psychoacoustic model.

**3.7 adaptive segmentation [audio]:** A subdivision of the digital representation of an audio signal in variable segments of time.

**3.8 alias [audio]:** Mirrored signal component resulting from sub-Nyquist sampling.

**3.9 analysis filterbank [audio]:** Filterbank in the encoder that transforms a broadband PCM audio signal into a set of subsampled subband samples.

**3.10 ancillary data [audio]:** part of the bitstream that might be used for transmission of ancillary data.

**3.11 audio access unit [audio]:** For Layers I and II, an audio access unit is defined as the smallest part of the encoded bitstream which can be decoded by itself, where decoded means "fully reconstructed sound". For Layer III, an audio access unit is part of the bitstream that is decodable with the use of previously acquired main information.

**3.12 audio buffer [audio]:** A buffer in the system target decoder for storage of compressed audio data.

**3.13 audio sequence [audio]:** A non-interrupted series of audio frames (base frames plus optional extension frames) in which the following parameters are not changed:


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- ID
- Layer
- Sampling Frequency

For Layer I and II, a decoder is not required to support a continuously variable bitrate (change in the bitrate index) of the base stream. Such a relaxation of requirements does not apply to the extension stream.

**3.14 B-field picture [video]:** A field structure B-Picture.

**3.15 B-frame picture [video]:** A frame structure B-Picture.

**3.16 B-picture; bidirectionally predictive-coded picture [video]:** A picture that is coded using motion compensated prediction from past and/or future reference fields or frames.

**3.17 backward compatibility:** A newer coding standard is backward compatible with an older coding standard if decoders designed to operate with the older coding standard are able to continue to operate by decoding all or part of a bitstream produced according to the newer coding standard.

**3.18 backward motion vector [video]:** A motion vector that is used for motion compensation from a reference frame or reference field at a later time in display order.

**3.19 backward prediction [video]:** Prediction from the future reference frame (field).

**3.20 Bark [audio]:** Unit of critical band rate. The Bark scale is a non-linear mapping of the frequency scale over the audio range closely corresponding with the frequency selectivity of the human ear across the band.

**3.21 base layer [video]:** First, independently decodable layer of a scalable hierarchy.

**3.22 big picture [video]:** A coded picture that would cause VBV buffer underflow as defined in C.7 Annex C of ISO/IEC 13818-2. Big pictures can only occur in sequences where low_delay is equal to 1. “Skipped picture” is a term that is sometimes used to describe the same concept.

**3.23 bitrate [audio]:** The rate at which the compressed bitstream is delivered to the input of a decoder.

**3.24 bitstream; stream:** An ordered series of bits that forms the coded representation of the data.

**3.25 bitstream verifier [video]:** A process by which it is possible to test and verify that all the requirements specified in ISO/IEC 13818-2 are met by the bitstream.

**3.26 block [video]:** An 8-row by 8-column matrix of samples, or 64 DCT coefficients (source, quantised or dequantised).

**3.27 block companding [audio]:** Normalising of the digital representation of an audio signal within a certain time period.

**3.28 bottom field [video]:** One of two fields that comprise a frame. Each line of a bottom field is spatially located immediately below the corresponding line of the top field.

**3.29 bound [audio]:** The lowest subband in which intensity stereo coding is used.

**3.30 byte aligned:** A bit in a coded bitstream is byte-aligned if its position is a multiple of 8-bits from the first bit in the stream.

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**3.31 byte:** Sequence of 8-bits.

**3.32 centre channel [audio]:** An audio presentation channel used to stabilise the central component of the frontal stereo image.

**3.33 channel [audio]:** A sequence of data representing an audio signal being transported.

**3.34 chroma simulcast [video]:** A type of scalability (which is a subset of SNR scalability) where the enhancement layer (s) contain only coded refinement data for the DC coefficients, and all the data for the AC coefficients, of the chrominance components.

**3.35 chrominance format [video]:** Defines the number of chrominance blocks in a macroblock.

**3.36 chrominance component [video]:** A matrix, block or single sample representing one of the two colour difference signals related to the primary colours in the manner defined in the bitstream. The symbols used for the chrominance signals are Cr and Cb.

**3.37 coded audio bitstream [audio]:** A coded representation of an audio signal as specified in part 3 of ISO/IEC 13818.

**3.38 coded B-frame [video]:** A B-frame picture or a pair of B-field pictures.

**3.39 coded frame [video]:** A coded frame is a coded I-frame, a coded P-frame or a coded B-frame.

**3.40 coded I-frame [video]:** An I-frame picture or a pair of field pictures, where the first field picture is an I-picture and the second field picture is an I-picture or a P-picture.

**3.41 coded order [video]:** The order in which the pictures are transmitted and decoded. This order is not necessarily the same as the display order.

**3.42 coded P-frame [video]:** A P-frame picture or a pair of P-field pictures.

**3.43 coded picture [video]:** A coded picture is made of a picture header, the optional extensions immediately following it, and the following picture data. A coded picture may be a coded frame or a coded field.

**3.44 coded representation:** A data element as represented in its encoded form.

**3.45 coded video bitstream [video]:** A coded representation of a series of one or more pictures as defined in ISO/IEC 13818-2.

**3.46 coding parameters [video]:** The set of user-definable parameters that characterise a coded bitstream. Bitstreams are characterised by coding parameters. Decoders are characterised by the bitstreams that they are capable of decoding.

**3.47 component [video]:** A matrix, block or single sample from one of the three matrices (luminance and two chrominance) that make up a picture.

**3.48 compression:** Reduction in the number of bits used to represent an item of data.

**3.49 constant bitrate:** Operation where the bitrate is constant from start to finish of the coded bitstream.


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**3.50 constrained parameters [video]:** The values of the set of coding parameters defined in 2.4.3.2 of ISO/IEC 11172-2.

**3.51 constrained system parameter stream; CSPS [systems]:** A Program Stream for which the constraints defined in 2.7.9 of ISO/IEC 13818-1 apply.

**3.52 CRC:** The Cyclic Redundancy Check to verify the correctness of data.

**3.53 critical band [audio]:** Psychoacoustic measure in the spectral domain which corresponds to the frequency selectivity of the human ear. This selectivity is expressed in Bark.

**3.54 critical band rate [audio]:** Psychoacoustic function of frequency. At a given audible frequency, it is proportional to the number of critical bands below that frequency. The units of the critical band rate scale are Barks.

**3.55 data element:** An item of data as represented before encoding and after decoding.

**3.56 data partitioning [video]:** A method for dividing a bitstream into two separate bitstreams for error resilience purposes. The two bitstreams have to be recombined before decoding.

**3.57 DC coefficient [video]:** The DCT coefficient for which the frequency is zero in both dimensions.

**3.58 DCT coefficient [video]:** The amplitude of a specific cosine basis function.

**3.59 de-emphasis [audio]:** Filtering applied to an audio signal after storage or transmission to undo a linear distortion due to emphasis.

**3.60 decoded stream:** The decoded reconstruction of a compressed bitstream.

**3.61 decoder input buffer [video]:** The first-in first-out (FIFO) buffer specified in the video buffering verifier.

**3.62 decoder:** An embodiment of a decoding process.

**3.63 decoder sub-loop [video]:** Stages within encoder which produce numerically identical results to the decode process described in ISO/IEC 13818-2 clause 7. Encoders capable of producing more than just I-pictures embed a decoder sub-loop to create temporal predictions and to model the behaviour of downstream decoders.

**3.64 decoding (process):** The process defined in ISO/IEC 13818 parts 1, 2 and 3 that reads an input coded bitstream and outputs decoded pictures or audio samples.

**3.65 decoding time-stamp; DTS [systems]:** A field that may be present in a PES packet header that indicates the time that an access unit is decoded in the system target decoder.

**3.66 dequantisation:** The process of rescaling the quantised DCT coefficients after their representation in the bitstream has been decoded and before they are presented to the inverse DCT.

**3.67 digital storage media; DSM:** A digital storage or transmission device or system.

**3.68 discrete cosine transform; DCT:** Either the forward discrete cosine transform or the inverse discrete cosine transform. The DCT is an invertible, discrete orthogonal transformation.

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**3.69 display aspect ratio [video]:** The ratio height/width (in SI units) of the intended display.

**3.70 display order [video]:** The order in which the decoded pictures are displayed. Normally this is the same order in which they were presented at the input of the encoder.

**3.71 display process [video]:** The (non-normative) process by which reconstructed frames are displayed.

**3.72 downmix [audio]:** A matrixing of n channels to obtain less than n channels.

**3.73 drift [video]:** Accumulation of mismatch between the reconstructed output produced by the hypothetical decoder sub-loop embedded within an encoder (see definition of "decoder sub-loop") and the reconstructed outputs produced by a (downstream) decoder.

**3.74 DSM-CC:** digital storage media command and control.

**3.75 dual channel mode [audio]:** A mode, where two audio channels with independent programme contents (e.g. bilingual) are encoded within one bitstream. The coding process is the same as for the stereo mode.

**3.76 dual-prime prediction [video]:** A prediction mode in which two forward field-based predictions are averaged. The predicted block size is 16x16 luminance samples. Dual-prime prediction is only used in interlaced P-pictures.

**3.77 dynamic crosstalk [audio]:** A method of multichannel data reduction in which stereo-irrelevant signal components are copied to another channel.

**3.78 dynamic transmission channel switching [audio]:** A method of multichannel data reduction by allocating the most orthogonal signal components to the transmission channels.

**3.79 editing:** The process by which one or more coded bitstreams are manipulated to produce a new coded bitstream. Conforming edited bitstreams must meet the requirements defined in parts 1, 2, and 3 of ISO/IEC 13818.

**3.80 Elementary Stream Clock Reference; ESCR [systems]:** A time stamp in the PES Stream from which decoders of PES streams may derive timing.

**3.81 elementary stream; ES [systems]:** A generic term for one of the coded video, coded audio or other coded bitstreams in PES packets. One elementary stream is carried in a sequence of PES packets with one and only one stream_id.

**3.82 emphasis [audio]:** Filtering applied to an audio signal before storage or transmission to improve the signal-to-noise ratio at high frequencies.

**3.83 encoder:** An embodiment of an encoding process.

**3.84 encoding (process):** A process, not specified in ISO/IEC 13818, that reads a stream of input pictures or audio samples and produces a valid coded bitstream as defined in parts 1, 2, and 3 of ISO/IEC 13818.

**3.85 enhancement layer [video]:** A relative reference to a layer (above the base layer) in a scalable hierarchy. For all forms of scalability, its decoding process can be described by reference to the lower layer decoding process and the appropriate additional decoding process for the enhancement layer itself.


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**3.86 entitlement control message; ECM [systems]:** Entitlement Control Messages are private conditional access information which specify control words and possibly other, typically stream-specific, scrambling and/or control parameters.

**3.87 entitlement management message; EMM [systems]:** Entitlement Management Messages are private conditional access information which specify the authorisation levels or the services of specific decoders. They may be addressed to single decoders or groups of decoders.

**3.88 entropy coding:** Variable length lossless coding of the digital representation of a signal to reduce redundancy.

**3.89 event [systems]:** An event is defined as a collection of elementary streams with a common time base, an associated start time, and an associated end time.

**3.90 evil bitstreams:** Bitstreams orthogonal to reality.

**3.91 extension bitstream [audio]:** Information contained in an optional additional bit stream related to the audio base bit stream at the system level, to support bit rates beyond those defined in ISO/IEC 11172-3. The optional extension bit stream contains the remainder of the multichannel and multilingual data.

**3.92 fast reverse playback [video]:** The process of displaying the picture sequence in the reverse of display order faster than real-time.

**3.93 fast forward playback [video]:** The process of displaying a sequence, or parts of a sequence, of pictures in display-order faster than real-time.

**3.94 FFT:** Fast Fourier Transformation. A fast algorithm for performing a discrete Fourier transform (an orthogonal transform).

**3.95 field [video]:** For an interlaced video signal, a “field” is the assembly of alternate lines of a frame. Therefore an interlaced frame is composed of two fields, a top field and a bottom field.

**3.96 field period [video]:** The reciprocal of twice the frame rate.

**3.97 field picture; field structure picture [video]:** A field structure picture is a coded picture with picture_structure is equal to "Top field" or "Bottom field".

**3.98 field-based prediction [video]:** A prediction mode using only one field of the reference frame. The predicted block size is 16x16 luminance samples. Field-based prediction is not used in progressive frames.

**3.99 filterbank [audio]:** A set of band-pass filters covering the entire audio frequency range.

**3.100 fixed segmentation [audio]:** A subdivision of the digital representation of an audio signal into fixed segments of time.

**3.101 flag:** A variable which can take one of only the two values defined in this specification.

**3.102 FLC:** Fixed Length Code.

**3.103 forbidden:** The term "forbidden", when used in the clauses defining the coded bitstream, indicates that the value shall never be used. This is usually to avoid emulation of start codes.

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**3.104 forced updating [video]:** The process by which macroblocks are intra-coded from time-to-time to ensure that mismatch errors between the inverse DCT processes in encoders and decoders cannot build up excessively.

**3.105 forward compatibility:** A newer coding standard is forward compatible with an older coding standard if decoders designed to operate with the newer coding standard are able to decode bitstreams of the older coding standard.

**3.106 forward motion vector [video]:** A motion vector that is used for motion compensation from a reference frame or reference field at an earlier time in display order.

**3.107 forward prediction [video]:** Prediction from the past reference frame (field).

**3.108 frame [audio]:** A part of the audio bit stream that corresponds to audio PCM samples from an Audio Access Unit.

**3.109 frame [video]:** A frame contains lines of spatial information of a video signal. For progressive video, these lines contain samples starting from one time instant and continuing through successive lines to the bottom of the frame. For interlaced video a frame consists of two fields, a top field and a bottom field. One of these fields may be temporally located one field period later than the other.

**3.110 frame period [video]:** The reciprocal of the frame rate.

**3.111 frame picture; frame structure picture [video]:** A frame structure picture is a coded picture with picture_structure is equal to "Frame".

**3.112 frame rate [video]:** The rate at which frames are be output from the decoding process.

**3.113 frame reordering [video]:** The process of reordering the reconstructed frames when the coded order is different from the display order. Frame reordering occurs when B-frames are present in a bitstream. There is no frame reordering when decoding low delay bitstreams.

**3.114 frame-based prediction [video]:** A prediction mode using both fields of the reference frame.

**3.115 free format [audio]:** Any bitrate other than the defined bitrates that is less than the maximum valid bitrate for each layer.

**3.116 future reference frame (field) [video]:** A future reference frame(field) is a reference frame(field) that occurs at a later time than the current picture in display order.

**3.117 granules [Layer II] [audio]:** The set of 3 consecutive subband samples from all 32 subbands that are considered together before quantisation. They correspond to 96 PCM samples.

**3.118 granules [Layer III] [audio]:** 576 frequency lines that carry their own side information.

**3.119 group of pictures [video]:** A notion defined only in ISO/IEC 11172-2 (MPEG-1 Video). In ISO/IEC 13818-2, a similar functionality can be achieved by the mean of inserting group of pictures headers.

**3.120 Hann window [audio]:** A time function applied sample-by-sample to a block of audio samples before Fourier transformation.

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**3.121 header:** A block of data in the coded bitstream containing the coded representation of a number of data elements pertaining to the coded data that follow the header in the bitstream.

**3.122 Huffman coding:** A specific method for entropy coding.

**3.123 hybrid filterbank [audio]:** A serial combination of subband filterbank and MDCT.

**3.124 hybrid scalability [video]:** Hybrid scalability is the combination of two (or more) types of scalability.

**3.125 I-field picture [video]:** A field structure I-Picture.

**3.126 I-frame picture [video]:** A frame structure I-Picture.

**3.127 I-picture; intra-coded picture [video]:** A picture coded using information only from itself.

**3.128 IDCT:** Inverse Discrete Cosine Transform.

**3.129 IMDCT [audio]:** Inverse Modified Discrete Cosine Transform.

**3.130 intensity stereo [audio]:** A method of exploiting stereo irrelevance or redundancy in stereophonic audio programmes based on retaining at high frequencies only the energy envelope of the right and left channels.

**3.131 interlace [video]:** The property of conventional television frames where alternating lines of the frame represent different instances in time. In an interlaced frame, one of the field is meant to be displayed first. This field is called the first field. The first field can be the top field or the bottom field of the frame.

**3.132 intra coding [video]:** Coding of a macroblock or picture that uses information only from that macroblock or picture.

**3.133 ITU-T Rec. H.222.0 | ISO/IEC 13818 (multiplexed) stream [systems]:** A bitstream composed of 0 or more elementary streams combined in the manner defined in ITU-T Rec. H.222.0 | ISO/IEC 13818-1.

**3.134 joint stereo coding [audio]:** Any method that exploits stereophonic irrelevance or stereophonic redundancy.

**3.135 joint stereo mode [audio]:** A mode of the audio coding algorithm using joint stereo coding.

**3.136 layer [audio]:** One of the levels in the coding hierarchy of the audio system defined in ISO/IEC 13818-3.

**3.137 layer [systems]:** One of the levels in the data hierarchy of the video and system specifications defined in ISO/IEC 13818 parts 1 and 2.

**3.138 layer [video]:** In a scalable hierarchy denotes one out of the ordered set of bitstreams and (the result of) its associated decoding process (implicitly including decoding of all layers below this layer).

**3.139 layer bitstream [video]:** A single bitstream associated to a specific layer (always used in conjunction with layer qualifiers, e. g. "enhancement layer bitstream").

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**3.140 level [video]:** A defined set of constraints on the values which may be taken by the parameters of this specification within a particular profile. A profile may contain one or more levels. In a different context, level is the absolute value of a non-zero coefficient (see “run”).

**3.141 LFE [audio]:** Low Frequency Enhancement channel. A limited bandwidth channel for low frequency audio effects in a multichannel system.

**3.142 low frequency enhancement channel [audio]:** A limited bandwidth channel for low frequency audio effects in a multichannel system.

**3.143 lower layer [video]:** A relative reference to the layer immediately below a given enhancement layer (implicitly including decoding of all layers below this enhancement layer).

**3.144 luminance component [video]:** A matrix, block or single sample representing a monochrome representation of the signal and related to the primary colours in the manner defined in the bitstream. The symbol used for luminance is Y.

**3.145 macroblock [video]:** The four 8 by 8 blocks of luminance data and the two (for 4:2:0 chrominance format), four (for 4:2:2 chrominance format) or eight (for 4:4:4 chrominance format) corresponding 8 by 8 blocks of chrominance data coming from a 16 by 16 section of the luminance component of the picture. Macroblock is sometimes used to refer to the sample data and sometimes to the coded representation of the sample values and other data elements defined in the macroblock header of the syntax defined in this part of this specification. The usage is clear from the context.

**3.146 mapping [audio]:** Conversion of an audio signal from time to frequency domain by subband filtering and/or by MDCT.

**3.147 masking [audio]:** A property of the human auditory system by which an audio signal cannot be perceived in the presence of another audio signal.

**3.148 masking threshold [audio]:** A function in frequency and time below which an audio signal cannot be perceived by the human auditory system.

**3.149 Mbit [video]:** 1 000 000 bits.

**3.150 MCP [video]:** Motion Compensated Predictor.

**3.151 MDCT [audio]:** Modified Discrete Cosine Transform which corresponds to the Time Domain Aliasing Cancellation Filter Bank.

**3.152 mismatch [video]:** Numerical discrepancy between the data reconstructed from the same coded bitstream by two decoding processes. With the exception of IDCT, the specification of ISO/IEC 13818-2 defines the decoding process absolutely unambiguously. Therefore, if both decoding processes are implemented according the specifications ISO/IEC 13818-2, mismatch can only be caused by different implementations of IDCT.

**3.153 motion compensation [video]:** The use of motion vectors to improve the efficiency of the prediction of sample values. The prediction uses motion vectors to provide offsets into the past and/or future reference frames or reference fields containing previously decoded sample values that are used to form the prediction error.

**3.154 motion estimation [video]:** The process of estimating motion vectors during the encoding process.


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**3.155 motion vector [video]:** A two-dimensional vector used for motion compensation that provides an offset from the coordinate position in the current picture or field to the coordinates in a reference frame or reference field.

**3.156 MS stereo [audio]:** A method of exploiting stereo irrelevance or redundancy in stereophonic audio programmes based on coding the sum and difference signal instead of the left and right channels.

**3.157 multichannel [audio]:** A combination of audio channels used to create a spatial sound field.

**3.158 multilingual [audio]:** A presentation of dialogue in more than one language.

**3.159 NIT [systems]:** Network Information Table as defined in table 2-23 of ISO/IEC 13818-1.

**3.160 non-intra coding [video]:** Coding of a macroblock or picture that uses information both from itself and from macroblocks and pictures occurring at other times.

**3.161 non-tonal component [audio]:** A noise-like component of an audio signal.

**3.162 Nyquist sampling:** Sampling at or above twice the maximum bandwidth of a signal.

**3.163 opposite parity [video]:** The opposite parity of top is bottom, and vice versa.

**3.164 P-field picture [video]:** A field structure P-Picture.

**3.165 P-frame picture [video]:** A frame structure P-Picture.

**3.166 P-picture; predictive-coded picture [video]:** A picture that is coded using motion compensated prediction from past reference fields or frame.

**3.167 pack [systems]:** A pack consists of a pack header followed by zero or more packets. It is a layer in the system coding syntax described in 2.5.3.3 on page 51 of ISO/IEC 13818-1.

**3.168 packet [systems]:** A packet consists of a header followed by a number of contiguous bytes from an elementary data stream. It is a layer in the system coding syntax described in 2.4.3 of ISO/IEC 13818-1.

**3.169 packet data [systems]:** Contiguous bytes of data from an elementary stream present in a packet.

**3.170 packet identifier; PID [systems]:** A unique integer value used to associate elementary streams of a program in a single or multi-program Transport Stream as described in 2.4.3 of ISO/IEC 13818-1.

**3.171 padding [audio]:** A method to adjust the average length of an audio frame in time to the duration of the corresponding PCM samples, by conditionally adding a slot to the audio frame.

**3.172 parameter:** A variable within the syntax of this specification which may take one of a range of values. A variable which can take one of only two values is a flag or indicator and not a parameter.

**3.173 parity (of field) [video]:** The parity of a field can be top or bottom.

**3.174 parser:** Functional stage of a decoder which extracts from a coded bitstream series of bits representing coded elements (FLC or VLC).

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**3.175 past reference frame (field) [video]:** A past reference frame(field) is a reference frame(field) that occurs at an earlier time than the current picture in display order.

**3.176 PAT [systems]:** Program Association Table as defined in clause 2.4.4.3 of ISO/IEC 13818-1.

**3.177 payload [systems]:** Payload refers to the bytes which follow the header bytes in a packet. For example, the payload of a Transport Stream packet includes the PES_packet_header and its PES_packet_data_bytes, or pointer_field and PSI sections, or private data; but a PES_packet_payload consists of only PES_packet_data_bytes. The Transport Stream packet header and adaptation fields are not payload.

**3.178 PES [systems]:** An abbreviation for Packetized Elementary Stream.

**3.179 PES packet [systems]:** The data structure used to carry elementary stream data. It consists of a PES packet header followed by PES packet payload and is described in 2.4.3.6 and 2.4.3.7 of ISO/IEC 13818-1.

**3.180 PES packet header[systems]:** The leading fields in a PES packet up to and not including the PES_packet_data_byte fields, where the stream is not a padding stream. In the case of a padding stream the PES packet header is similarly defined as the leading fields in a PES packet up to and not including padding_byte fields.

**3.181 PES Stream [systems]:** A PES Stream consists of PES packets, all of whose payloads consist of data from a single elementary stream, and all of which have the same stream_id. Specific semantic constraints apply.

**3.182 picture [video]:** Source, coded or reconstructed image data. A source or reconstructed picture consists of three rectangular matrices of 8-bit numbers representing the luminance and two chrominance signals. A “coded picture” is defined in ISO/IEC 13818-2. For progressive video, a picture is identical to a frame, while for interlaced video, a picture can refer to a frame, or the top field or the bottom field of the frame depending on the context.

**3.183 picture data [video]:** In the VBV operations, picture data is defined as all the bits of the coded picture, all the header(s) and user data immediately preceding it if any (including any stuffing between them) and all the stuffing following it, up to (but not including) the next start code, except in the case where the next start code is an end of sequence code, in which case it is included in the picture data.

**3.184 polyphase filterbank [audio]:** A set of equal bandwidth filters with special phase interrelationships, allowing for an efficient implementation of the filterbank.

**3.185 prediction [audio]:** The use of a predictor to provide an estimate of the subband sample in one channel from the subband samples in other channels.

**3.186 prediction error:** The difference between the actual value of a sample or data element and its predictor.

**3.187 prediction:** The use of a predictor to provide an estimate of the sample value or data element currently being decoded.

**3.188 predictor:** A linear combination of previously decoded sample values or data elements.

**3.189 presentation channel [audio]:** audio channels at the output of the decoder corresponding to the loudspeaker positions left, centre, right, left surround and right surround.


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**3.190 presentation time-stamp; PTS [systems]:** 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.

**3.191 presentation unit; PU [systems]:** A decoded Audio Access Unit or a decoded picture.

**3.192 profile [video]:** A defined subset of the syntax of this specification.

**3.193 profile-and-level combination [video]:** Point of conformance for video bitstreams and decoders. Defined profile-and-level combinations are defined in Chapter 8 of ISO/IEC 13818-2. In the case of a bitstream, the profile-and-level combination is derived from the profile_and_level_indication. A decoder may comply with several profile-and level combinations.

**3.194 program [systems]:** A program is a collection of program elements. Program elements may be elementary streams. Program elements need not have any defined time base; those that do, have a common time base and are intended for synchronised presentation.

**3.195 Program Clock Reference; PCR [systems]:** A time stamp in the Transport Stream from which decoder timing is derived.

**3.196 program element[systems]:** A generic term for one of the elementary streams or other data streams that may be included in a program.

**3.197 Program Specific Information; PSI [systems]:** PSI consists of normative data which is necessary for the demultiplexing of Transport Streams and the successful regeneration of programs and is described in 2.4.4 of ISO/IEC 13818-1. One case of PSI, the non-mandatory network information table, is privately defined.

**3.198 progressive [video]:** The property of film frames where all the samples of the frame represent the same instances in time.

**3.199 psychoacoustic model [audio]:** A mathematical model of the masking behaviour of the human auditory system.

**3.200 quantisation matrix [video]:** A set of sixty-four 8-bit values used by the dequantiser.

**3.201 quantised DCT coefficients [video]:** DCT coefficients before dequantisation. A variable length coded representation of quantised DCT coefficients is transmitted as part of the coded video bitstream.

**3.202 quantiser scale [video]:** A scale factor coded in the bitstream and used by the decoding process to scale the dequantisation.

**3.203 random access:** The process of beginning to read and decode the coded bitstream at an arbitrary point.

**3.204 reconstructed frame [video]:** A reconstructed frame consists of three rectangular matrices of 8-bit numbers representing the luminance and two chrominance signals. A reconstructed frame is obtained by decoding a coded frame.

**3.205 reconstructed picture [video]:** A reconstructed picture is obtained by decoding a coded picture. A reconstructed picture is either a reconstructed frame (when decoding a frame picture), or one field of a reconstructed frame (when decoding a field picture). If the coded picture is a field picture, then the reconstructed picture is the top field or the bottom field of the reconstructed frame.

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**3.206 reference decoder [video]:** A decoder that implements precisely the decoding process as specified in ISO/IEC 13818-2 and uses a reference IDCT. The reference decoder is capable of decoding compliant bitstreams of any defined profile-and-level.

**3.207 reference IDCT [video]:** Embodiment of the saturated mathematical integer-number IDCT specified in Annex A of ISO/IEC 13818-2.

**3.208 reference field [video]:** A reference field is one field of a reconstructed frame. Reference fields are used for forward and backward prediction when P-pictures and B-pictures are decoded. Note that when field P-pictures are decoded, prediction of the second field P-picture of a coded frame uses the first reconstructed field of the same coded frame as a reference field.

**3.209 reference frame [video]:** A reference frame is a reconstructed frame that was coded in the form of a coded I-frame or a coded P-frame. Reference frames are used for forward and backward prediction when P-pictures and B-pictures are decoded.

**3.210 reordering delay [video]:** A delay in the decoding process that is caused by frame reordering.

**3.211 requantisation [audio]:** Decoding of coded subband samples in order to recover the original quantised values.

**3.212 reserved:** The term "reserved" when used in the clauses defining the coded bitstream indicates that the value may be used in the future for ISO/IEC defined extensions.

**3.213 run [video]:** The number of zero coefficients preceding a non-zero coefficient, in the scan order. The absolute value of the non-zero coefficient is called “level”.

**3.214 sample aspect ratio [video]:** (abbreviated to SAR). This specifies the distance between samples. It is defined (for the purposes of this specification) as the vertical displacement of the lines of luminance samples in a frame divided by the horizontal displacement of the luminance samples. Thus its units are (metres per line) ÷ (metres per sample).

**3.215 saturation [video]:** Limiting a value that exceeds a defined range by setting its value to the maximum or minimum of the range as appropriate.

**3.216 scalability [video]:** Scalability is the ability of a decoder to decode an ordered set of bitstreams to produce a reconstructed sequence. Moreover, useful video is output when subsets are decoded. The minimum subset that can thus be decoded is the first bitstream in the set which is called the base layer. Each of the other bitstreams in the set is called an enhancement layer. When addressing a specific enhancement layer, "lower layer" refer to the bitstream which precedes the enhancement layer.

**3.217 scalable hierarchy [video]:** coded video data consisting of an ordered set of more than one video bitstream.

**3.218 scalefactor [audio]:** Factor by which a set of values is scaled before quantisation.

**3.219 scalefactor band [audio]:** A set of frequency lines in Layer III which are scaled by one scalefactor.

**3.220 scalefactor index [audio]:** A numerical code for a scalefactor.


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**3.221 scrambling [systems]:** The alteration of the characteristics of a video, audio or coded data stream in order to prevent unauthorised reception of the information in a clear form. This alteration is a specified process under the control of a conditional access system.

**3.222 side information:** Information in the bitstream necessary for controlling the decoder.

**3.223 skipped macroblock [video]:** A macroblock for which no data is encoded.

**3.224 slice [video]:** A series of consecutive macroblocks that start, in the coded bitstream, by a slice_start_code and that continue up to the next start code (or to the first stuffing bytes if the next start_code is preceded by stuffing bytes)..

**3.225 slot [audio]:** A slot is an elementary part in the audio bit stream. In Layer I a slot equals four bytes, in Layers II and III one byte.

**3.226 SNR scalability [video]:** A type of scalability where the enhancement layer (s) contain only coded refinement data for the DCT coefficients of the lower layer.

**3.227 source stream:** A single non-multiplexed stream of samples before compression coding.

**3.228 source; input [video]:** Term used to describe the video material or some of its attributes before encoding.

**3.229 spatial prediction [video]:** prediction derived from a decoded frame of the lower layer decoder used in spatial scalability.

**3.230 spatial scalability [video]:** A type of scalability where an enhancement layer also uses predictions from sample data derived from a lower layer without using motion vectors. The layers can have different frame sizes, frame rates or chrominance formats.

**3.231 splicing[systems]:** The concatenation, performed on the system level, of two different elementary streams. The resulting system stream conforms totally to ISO/IEC 13818-1. The splice may result in discontinuities in timebase, continuity counter, PSI, and decoding.

**3.232 spreading function [audio]:** A function that describes the frequency spread of masking effects.

**3.233 start codes [systems]:** 32-bit codes embedded in the coded bitstream that are unique. They are used for several purposes including identifying some of the layers in the coding syntax.

**3.234 STD input buffer [systems]:** A first-in first-out buffer at the input of a system target decoder for storage of compressed data from elementary streams before decoding.

**3.235 stereo mode [audio]:** Mode, where two audio channels which form a stereo pair (left and right) are encoded within one bitstream. The coding process is the same as for the dual channel mode.

**3.236 stereo-irrelevant [audio]:** a portion of a stereophonic audio signal which does not contribute to spatial perception.

**3.237 still picture [systems]:** A coded still picture consists of a video sequence containing exactly one coded picture which is intra-coded. This picture has an associated PTS and the presentation time of succeeding pictures, if any, is later than that of the still picture by at least two picture periods.

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**3.238 stuffing (bits); stuffing (bytes):** Code-words that may be inserted at particular locations in the coded bitstream that are discarded in the decoding process. Their purpose is to increase the bitrate of the stream which would otherwise be lower than the desired bitrate.

**3.239 subband [audio]:** Subdivision of the audio frequency band.

**3.240 subband filterbank [audio]:** A set of band filters covering the entire audio frequency range. In ISO/IEC 13818-3, the subband filterbank is a polyphase filterbank.

**3.241 subband samples [audio]:** The subband filterbank within the audio encoder creates a filtered and subsampled representation of the input audio samples. The filtered samples are called subband samples. From 32 time-consecutive input audio samples, one subband sample is generated within each of the 32 subbands.

**3.242 surround channel [audio]:** An audio presentation channel added to the front channels (L and R or L, R, and C) to enhance the spatial perception.

**3.243 syncword [audio]:** A 12-bit code embedded in the audio bit stream that identifies the start of a base frame or an extension frame.

**3.244 synthesis filterbank [audio]:** Filterbank in the decoder that reconstructs a PCM audio signal from subband samples.

**3.245 System Clock Reference; SCR [systems]:** A time stamp in the Program Stream from which decoder timing is derived.

**3.246 system header [systems]:** The system header is a data structure defined in subclause 2.5.3.5 of ISO/IEC 13818-1, that carries information summarising the system characteristics of the ITU-T Rec. H.222.0 | ISO/IEC 13818 multiplexed Program Stream.

**3.247 system target decoder; STD [systems]:** A hypothetical reference model of a decoding process used to describe the semantics of an ITU-T Rec. H.222.0 | ISO/IEC 13818 multiplexed bitstream.

**3.248 temporal prediction [video]:** prediction derived from reference frames or fields other than those defined as spatial prediction.

**3.249 temporal scalability [video]:** A type of scalability where an enhancement layer also uses predictions from sample data derived from a lower layer using motion vectors. The layers have identical frame size, and chrominance formats, but can have different frame rates.

**3.250 time-stamp [systems]:** A term that indicates the time of a specific action such as the arrival of a byte or the presentation of a Presentation Unit.

**3.251 tonal component [audio]:** A sinusoid-like component of an audio signal.

**3.252 top field [video]:** One of two fields that comprise a frame. Each line of a top field is spatially located immediately above the corresponding line of the bottom field.

**3.253 top layer [video]:** the topmost layer (with the highest layer_id) of a scalable hierarchy.

**3.254 Transport Stream packet header [systems]:** The leading fields in a Transport Stream packet, up to and including the continuity_counter field.


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**3.255 triplet [audio]:** A set of 3 consecutive subband samples from one subband. A triplet from each of the 32 subbands forms a granule.

**3.256 variable bitrate:** Operation where the bitrate varies with time during the decoding of a coded bitstream.

**3.257 variable length coding:** A reversible procedure for coding that assigns shorter code-words to frequent events and longer code-words to less frequent events.

**3.258 VLC:** Variable Length Code.

**3.259 VLD:** Variable Length Decoder.

**3.260 video buffering verifier; VBV [video]:** A hypothetical decoder that is conceptually connected to the output of the encoder. Its purpose is to provide a constraint on the variability of the data rate that an encoder or editing process may produce.

**3.261 video sequence [video]:** The highest syntactic structure of coded video bitstreams. It contains a series of one or more coded frames.

**3.262 xxx profile bitstream [video]:** a bitstream of a scalable hierarchy with a profile indication corresponding to xxx. Note that this bitstream is only decodable together with all its lower layer bitstreams (unless it is a base layer bitstream).

**3.263 xxx profile decoder [video]:** decoder able to decode one or a scalable hierarchy of bitstreams of which the top layer conforms to the specifications of the xxx profile (with xxx being any of the defined Profile names).

**3.264 xxx profile scalable hierarchy [video]:** set of bitstreams of which the top layer conforms to the specifications of the xxx profile.

**3.265 zig-zag scanning order [video]:** A specific sequential ordering of the DCT coefficients from (approximately) the lowest spatial frequency to the highest.

## 4 Symbols and abbreviations

The ISO/IEC 9899:1999 standard for C and the ISO standard for C++ programming language specify the syntax used in this document. ISO C and C++ require adherence to IEEE standards which specify numerical accuracy and rounding behavior for mathematical operators.

## 5 Systems simulation

This is Release 1.0 of the MSYS Toolkit, a set of C++ classes for building and manipulating MPEG System streams. With these classes one build MPEG System multiplexors and demultiplexors and other MPEG System-related applications. Examples of an encoder (in encode.C) and a decoder (in decode.C) are provided.

The software is included in electronic format with this document as systems.zip.

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# 6 Video simulation

This clause contains the implementation of an ISO/IEC 13818-2 codec. The encoder software can generate bitstreams without scalability. The decoder can decode bitstreams with SNR and spatial scalability. Also the decoding of the 4:2:2-profile is implemented.

The decoder software provides the following options that are necessary for the conformance test as described in ISO/IEC 13818-4 :

- bitstream verification,
- decoding with the frame buffer intercept method of ISO/IEC 13818-4,
- decoding with a double precision floating point IDCT

The software is included in electronic format with this document as video.zip. It consists of the following parts:

- documentation (README and doc directory)
- encoder (encoder directory)
- decoder (decoder directory)
- parameter files (par directory)

# 7 Audio simulation

## 7.1 Layer 1, Layer 2 and Layer 3

This technical report contains the implementation of an ISO/IEC 13818-3 codec. The components of the audio codec software (distribution 11) are:

- full layer 2 multichannel decoder
- near-full layer 2 multichannel encoder (omits prediction with non-zero delay)
- full layers 1-3 low-sampling frequency encoder and decoder

### 7.1.1 Software listings

The ISO/IEC TR 13818-5 software for layer 1, layer 2 and layer 3 is included in electronic format with this document as mpeg2audio.zip. It consists of the following parts:

- documentation
- low sampling frequency encoder
- low sampling frequency decoder
- multi-channel encoder
- multi-channel decoder

## 7.2 AAC

This technical report contains the implementation of an ISO/IEC 13818-7 codec. The ISO/IEC TR 13818-5 software for AAC is included in electronic format with this document as mpeg2aac.zip. It consists of the following parts:

- documentation


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- AAC encoder
- AAC decoder
- conformance test tool

# 8 MPEG-2 IPMP Reference Software

## 8.1 Architecture

The codes of MPEG-2 IPMP reference software are developed with C++ on Windows Platform. However, the normative parts of the reference software don't use Windows specific libraries or functions. So it is quite easy to transport the codes to other platforms as well.

The major IPMP functionalities are encapsulated in a demultiplex filter, which uses Microsoft's DirectX technology. Doing that not only gives an easy terminal implementation, which needs to deal with demultplexing, decoding and rendering, but also brings the benefits of a clear terminal architecture. The general architecture of the software is shown in Figure 1. Based on this given architecture, a general data flow in a MPEG-2 IPMP terminal is described as below,

An input MPEG-2 Transport Stream (TS) is fed into a demultiplex filter, which decomposes the system stream into individual elementary streams. Before the TS stream is demultiplexed, the IPMP information carried inside are extracted and processed first. IPMP related actions are taken according to the processing results. For example, if the rights condition of the TS stream is not fulfilled, further processing will be terminated and user will be prompted of the rights failure. Furthermore, global initializations are also carried upon here, e.g., checking the availability the IPMP tools specified in the IPMP Tool List, retrieving the tools in case they don't exist in terminal, etc.

The TS stream is then demultplexed into elementary streams, typically video streams and audio streams. Before elementary streams are input to their respective decoder filters, IPMP processing is involved again, if one stream has IPMP control point set before the decoder, i.e., the IPMP descriptors associated with this stream explicitly request that data in the pre-decoder buffer need to be processed first by certain IPMP Tools, which are also specified in the IPMP descriptors. For example, decryption tools are needed to transcode encrypted data back to clear data before they can be correctly processed by decoder.

After the stream data go through the decoder filter, they are input to render filter. Before the render presents the data, IPMP is involved again to check whether the data in the pre-render buffer need to be processed by some IPMP tools first. For example, watermarking tools are used to extract signatures hidden in the stream data.

At last, the render filters present the clear stream data on user's terminals.

The internal communication between tools and terminal is in the form of IPMP messages, which are normative parts of the IPMP standard. All MPEG-2 IPMP compatible terminal and tools should understand the content of an IPMP message.

Message Routers act as an agent in the IPMP terminal. It takes charge of message sending and receiving between terminal and tools. If one tool needs to send message to another tool, the message also needs to go through terminal's Message Router and redirected to its destination. However, the interfaces between Message Router and IPMP Tools are not standardized. So the implementation can vary in different platforms and applications. This software just gives a reference implementation of the Message Router and reference model how the Message Router can facilitate the message delivering between IPMP Terminal and IPMP tools. Users are not limited by the reference implementation and free to extend from it by their wills.

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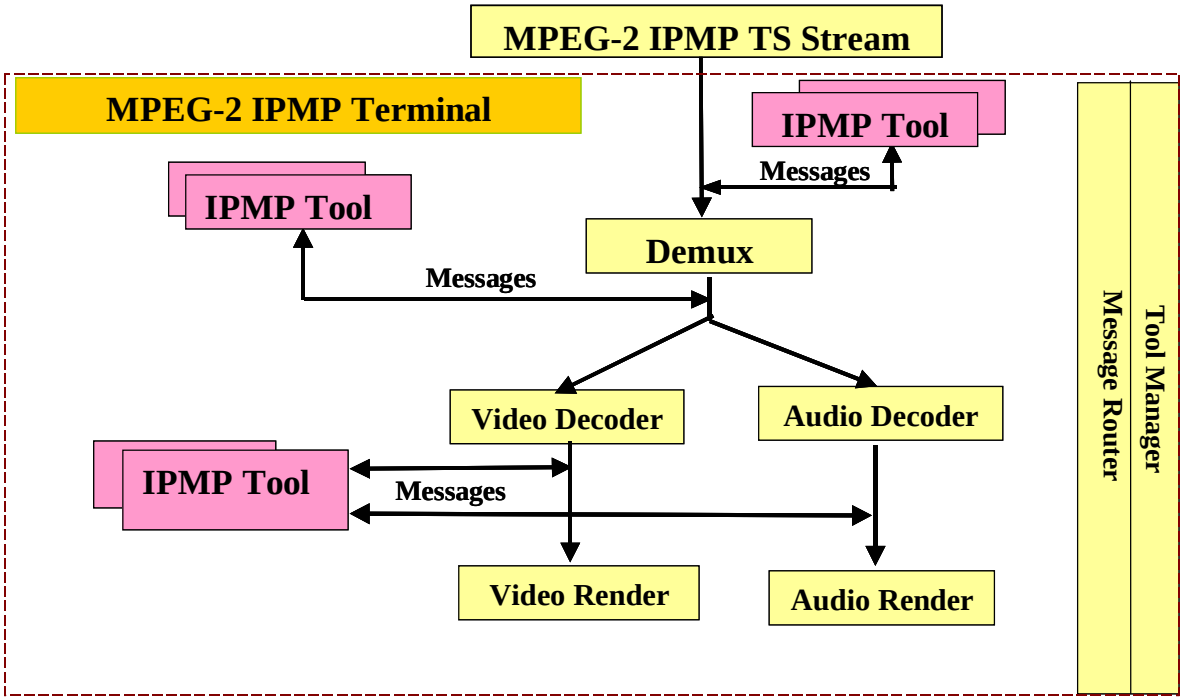


**Figure 1 — MPEG-2 IPMP Terminal Architecture**

Tool Manager acts as an agent to manage IPMP Tools in IPMP Terminal, e.g., loading IPMP Tool, connecting to IPMP Tool, unloading IPMP Tool, etc. Similar as Message Router, its interfaces are not standardized also. This software gives a reference implementation of the Tool Manager. Users of the software are not limited to extend its functionalities by their wills.

The following section introduces the implemented core components in details.

## 8.2 Core Components

### 8.2.1 IPMP Tool List – Normative

IPMP Tool List is carried in TS stream's PSI table. It gives the information of IPMP Tools to be used to process the given stream.

In the reference software, the modules related with IPMP Tool List are included in the demultiplex filter.

### 8.2.2 IPMP Tool Container – Normative

IPMP Tool Container is carried in TS streams' PSI table. It is able to carry binary IPMP Tools. One possible scenario to use this feature is tool vendor wants to update or upgrade a updated tool with a later version.

In the reference software, the modules related with IPMP Tool Container are included in the demultiplex filter.

### 8.2.3 IPMP Rights Container - Normative

IPMP Rights Container is carried in TS streams' PSI table. It carries rights information associated with the host stream. The rights information should be extracted by the Terminal and processed by specified IPMP Tools.


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In the reference software, the modules related with IPMP Rights Container are included in the demultiplex filter.

### 8.2.4 IPMP Descriptor – Normative

IPMP Descriptor is carried in TS stream's PMT table. Each descriptor is associated with an elementary stream, i.e., audio or video. Each descriptor specifies an IPMP Tool to be used to process the stream. The control point is given to tell terminal at what stage the tool to be applied.

In the reference software, the modules related with IPMP Descriptor are included in the demultiplex filter.

### 8.2.5 IPMP Messages – Normative

IPMP Messages are used to pass data and information between IPMP Terminal and IPMP Tools to facilitate IPMP processing.

There are 24 messages, listed in Table 1, defined in the MPEG-2 IPMP standard. All of them have been implemented in the reference software. They are encapsulated in an individual message library for user convenience.

**Table 1 — MPEG-2 IPMP Messages**

| 8-bit Tag Value | Symbolic Name |
|---|---|
| 0x00 | Forbidden |
| 0x01 | IPMP_OpaqueData_tag |
| 0x02 | IPMP_AudioWatermarkingInit_tag |
| 0x03 | IPMP_VideoWatermarkingInit _tag |
| 0x04 | IPMP_SelectiveDecryptionInit_tag |
| 0x05 | IPMP_KeyData _tag |
| 0x06 | IPMP_SendAudioWatermark_tag |
| 0x07 | IPMP_SendVideoWatermark _tag |
| 0x08 | IPMP_RightsData _tag |
| 0x09 | IPMP_Secure_Container_tag |
| 0x0A | IPMP_AddToolNotificationListener_tag |
| 0x0B | IPMP_RemoveToolNotificationListener_tag |
| 0x0C | IPMP_InitAuthentication_tag |
| 0x0D | IPMP_MutualAuthentication_tag |
| 0x0E | IPMP_UserQuery_tag |
| 0x0F | IPMP_UserQueryResponse_tag |
| 0x10 | IPMP_ToolParamCapabilitiesQuery_tag |
| 0x11 | IPMP_ToolParamCapabilitiesResponse_tag |
| 0x12 | IPMP_GetTools_tag |
| 0x13 | IPMP_GetToolsResponse_tag |
| 0x14 | IPMP_ConnectTool_tag |
| 0x15 | IPMP_DisconnectTool_tag |
| 0x16 | IPMP_NotifyToolEvent_tag |
| 0x17 | IPMP_CanProcess_tag |
| 0x18 | IPMP_TrustSecurityMetadata_tag |
| 0x19– 0x3F | Reserved for Inter-device messages |
| 0x40 – 0xCF | ISO Reserved |

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| | |
|---|---|
| 0xD0 – 0xFE | User Defined |
| 0xFF | Forbidden |

### 8.2.6 IPMP Stream - Normative

IPMP Stream carries multiple IPMP Messages, which are packed by IPMP_StreamDataUpdate message. Multiple continuous IPMP_StreamDataUpdate messages can be concatenated together to form IPMP stream. One usage of this stream is to carry time-variant key data, and multiplex together with video or audio elementary streams. Upon receiving IPMP_StreamDataUpdate message, the Message Router will unpack the IPMP_StreamDataUpdate message and extract the inside messages for further processing.

The following three messages are used to facilitate the message delivery between terminal and tools. Table 2 lists what MPEG-2 IPMP has defined.

**Table 2 — MPEG-2 IPMP Facilitating Messages**

| 8-bit Tag Value | Symbolic Name |
|---|---|
| 0x00 | Forbidden |
| 0x01 | IPMP_MessageFromBitstream_tag |
| 0x02 | IPMP_DescriptorFromBitstream_tag |
| 0x03 | IPMP_MessageFromTool_tag |
| 0x04 – 0xCF | ISO Reserved |
| 0xD0 – 0xFE | User Defined |
| 0xFF | Forbidden |

In the reference software, all above messages have been implemented in the Message library.

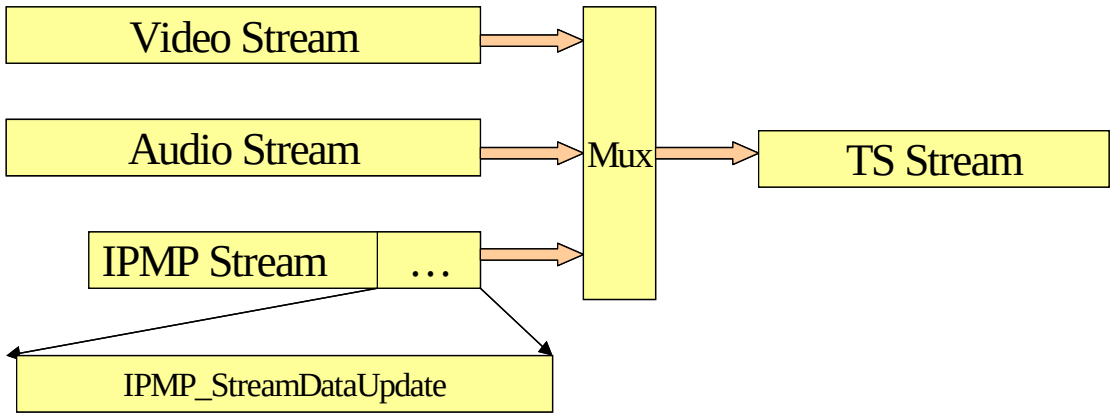


**Figure 2 — IPMP Stream and other elementary streams**

### 8.2.7 Message Router – Informative

Message Router manages the message delivery between Terminal and IPMP Tools. Because the practical applications could base on different platforms and have different context, the interfaces of Message Router exposed to IPMP Terminal and IPMP Tool aren't standardized. In this reference software, Class *CPSLMR* implements the major functionalities that a Message Router should have, that are receiving and delivering messages. The interfaces used by *CPSLMR* act just as reference for other users.

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In the reference software, Message Router functions are encapsulated in class *CPSLMR,* which are used by the IPMP Terminal.

### 8.2.8 Tool Manager – Informative

Tool Manager manages the IPMP Tools used to process the input stream, e.g., loading the tools given in the IPMP Tool List, connecting the terminal with IPMP Tool, etc. Because the practical applications could base on different platforms and have different context, the interfaces of Tool Manager to IPMP Terminal and IPMP Tool aren't standardized. In this reference software, Class *IPMPToolManagerImp* implements the major functionalities that a Tool Manager should have. The interfaces used by *IPMPToolManagerImp* act just as reference for other users.

In the reference software, Tool Manager functions are encapsulated in class *IPMPToolManagerImp,* which are used by the IPMP Terminal.

### 8.2.9 IPMP Terminal – Informative

IPMP Terminal controls the whole process of input MPEG-2 IPMP stream. In the reference software implementation, the IPMP Terminal controls IPMP processing, demultiplexing, decoding and rendering.

In the reference software, IPMP Terminal's code is in *PlayWnd* project.

### 8.2.10 Multiplexer – Informative

For the convenience of MPEG-2 IPMP TS stream generation, the reference software also provides a multiplexer, a standalone application. It can multiplex MPEG-2 format video stream and MPEG-1 audio stream into MPEG-2 transport stream. According to the configuration, it can multiplex IPMP information into the TS, e.g., IPMP stream, IPMP Tool List, IPMP Tool Container, IPMP Rights Container, IPMP Descriptor, etc.

Furthermore, reference software provides a DES encryption/decryption tool to work together with the multiplexer. Users can encrypt elementary streams with this DES tool and multiplex the transformed stream into TS stream.

Please read the Readme.txt file under the *tsmuxer* project directory to get more details about how to use this application. Sample parameter file together with some descriptor data are provided to give users a startup example.

In the reference software, multiplexer's code is organized in *Tsmux* project.

### 8.2.11 IPMP Tool - Informative

One important principle of developing MPEG-2 IPMP standard is to achieve interoperability. The standard aims to provide a flexible framework to allow any compatible tools to interact each other, instead of the limitation of certain specific tools. Due to this consideration, there are no specific IPMP Tools defined. Any tools that process or governs the media stream data can be used as IPMP Tools as long as they can handle IPMP messages.

In the reference software, we provide 3 IPMP tools to demonstrate how IPMP Terminal and IPMP Tool interact each other. In the reference implementation, all IPMP tools are in the form of DLL libraries. They expose one and only one interface to the IPMP Terminal:

*BOOL ToolInterface(unsigned int sender, unsigned int recipient, long size, byte* message) (1)*

*sender:* the descriptor ID of message sender

*recipient:* the descriptor ID of message receiver

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*size:* the size of this message

*message:* binary data of the message

Vice versa, the IPMP Terminal exposes the same interface the IPMP Tool as well to enable messages circulated between Terminal and Tools. The Terminal's public interface is,

*BOOL MR_Interface(unsigned int Sender, unsigned int Recipient, long size, byte* message) (2)*

It takes the same parameter as IPMP Tools.

In the reference software, the connection between Terminal and an IPMP Tool A is setup like following:

Step1: Terminal loads Tool A's Dll file

Step2: Terminal acquires Tool A's public interface, which is (1) as above

Step3: Terminal packs the pointer of its public interface, which is (2), in a IPMP_OpaqueData message, and send the message through (1) it gets from Step 2. In the reference code, we have a member function defined in the Message Router to do this:

*Send_MRReceiveMessagePtr(unsigned int Recipient)*

*Recipient: the descriptor ID associated with the tool to receive this message*

Step 4: Tool A receives a IPMP_OpaqueData message, which contains certain identifiers telling this is a interface pointer from Terminal. Tool A saves the pointer for future use.

By then, the connection setup between Terminal and Tool A is done. They both have known their counterpart's interface and are able to send/receive messages each other.

As have been said, this is only reference implementation. Other applications can do this in more constructive ways.

Three IPMP Tools provided by the reference software are,

- DES Tool

This DES tool is able to encrypt/decrypt data with 64, 128 or 196 bits keys.

In the reference software, the codes of this DES decryption tool are in project *DESDLL*.

- REL (Rights Expression Language) Tool

This tool provides REL functions to validate Rights data in the form of MPEG-21 REL.

In the reference software, the codes of this REL Tool are in project *RELTool*.

- Dummy Tool


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A dummy tool which simply accepts media streams from message router and returns without any processing. It can be easily extended to perform watermarking or encryption processing.

In the reference software, the codes of this Dummy Tool are in project *DummyTool*.

## 8.3 Usage of the Reference Software

### 8.3.1 Building the Reference Software

The reference software codes are developed with Microsoft Visual C++ 6.0 on Windows platform. Please use Microsoft's Visual Studio to open each workspace introduced below and build them individually.

### 8.3.2 Workspace MPEG2SplitterFilter

The workspace *MPEG2SplitterFilter.dsw* contains 4 projects. They are,

- *PSL MPEG2 MessageInterface.dsp* under subdirectory MessageInterface.

This project contains the codes of IPMP Messages and the handling of the messages. The output of this project is *PSLMPEG2MessageInterface.lib*.

- *MPEG2Splitter.dsp* under subdirectory PSLMPEG2Lib.

This project contains the codes of core IPMP related functionalities, including Tool List, Tool Container, and Rights Container handling, Tool Manager and Message Router. The output of this project is *MPEG2Splitter.lib* which is to be used by the following filter project

- *MPEG2SplitterFilter.dsp* in the same directory.

This project contains the codes of demultiplex filter. It will use the library functions in the above *MPEG2Splitter.lib.* The output of this project is *PSLMPEG2SplitterFilter.ax*.

Note, to launch the IPMP Terminal, the filter *PSLMPEG2SplitterFilter.ax* has to be registered in prior. Users can use Microsoft Visual Studio's Tools->Register Controls to register the filter.

- *PlayWnd.dsp* under subdirectory PSLPlayer.

This project contains the codes of IPMP Terminal. It is developed based on DirectShow. So users are required to install DirectX first to get the project build successfully. Users can go to Microsoft's website to get the latest DirectX developed package, which is free of charge. The output of this project is *playwnd.exe*.

### 8.3.3 Workspace Tsmuxer

The workspace *tsmuxer.dsw* contains 2 projects. They are,

- *PSL MPEG2 MessageInterface.dsp under subdirectory MessageInterface.*

This project contains the codes of IPMP Messages and the handling of the messages. They could be used by the multiplexer to generate IPMP message carried in the IPMP Stream. The output of this project is *PSLMPEG2MessageInterface.lib*.

Note, this project should be the same as the message project introduced above. Any changes to either project must be synchronised.

- *Tsmuxer.dsp* in the same directory.

This project contains the codes of reference multiplexer. The output of this project is a tsmuxer.exe.

- README and Sample configuration files under subdirectory Sample

A README file is provided as a user-manual to the Tsmuxer application. Also sample parameter files and sample descriptor data are provided to give users a start-up point.

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### 8.3.4 Workspace DESDLL

The workspace *desdll.dsw* contains 2 projects. They are,

- *PSL MPEG2 MessageInterface.dsp* under subdirectory MessageInterface.

This project contains the codes of IPMP Messages and the handling of the messages. They are used by IPMP Tools, DES decryption tool in this case, to receive message from Terminal and generate messages to be sent back to Terminal. The output of this project is *PSLMPEG2MessageInterface.lib*.

Note, this project is the same as the message projects introduced above. Any changes to either project must be synchronised.

- *Desdll.dsp* in the same directory.

This project contains the codes of DES decryption tool. Besides the DES decryption functions, it has a Message Router as well to send and receive IPMP Messages. The interfaces between the tool and terminal are informative. The output of this project is *desdll.dll*.

### 8.3.5 Workspace RELTool

The workspace *RELTool.dsw* contains 2 projects. They are,

- *PSL MPEG2 MessageInterface.dsp* under subdirectory MessageInterface.

This project contains the codes of IPMP Messages and the handling of the messages. They are used by IPMP Tools, REL tool in this case, to receive message from Terminal and generate messages to be sent back to Terminal. The output of this project is *PSLMPEG2MessageInterface.lib*.

Note, this project is the same as the message projects introduced above. Any changes to either project must be synchronised.

- *RELTool.dsp* in the same directory.

This project contains the message related codes of the REL tool. Besides the REL parsing and processing functions, it can also send and receive IPMP Messages. The interfaces between the tool and terminal are informative. The output of this project is *RELTool.dll*.

- *RightsManagementTool.dsp* and *RELLicAuthz.dsp*

These two projects contain core codes of REL functions.

Note: users have to install Microsoft's MSXML 4.0 above to compile these projects because they used the XML functions provided by MSXML. We provide the MSXML installer file **msxml.msi** under directory RELTool for user convenience.

### 8.3.6 Workspace DummyTool

The workspace *DummyTool.dsw* contains 2 projects. They are,

- *PSL MPEG2 MessageInterface.dsp* under subdirectory MessageInterface.

This project contains the codes of IPMP Messages and the handling of the messages. They are used by IPMP Tools, Dummy tool in this case, to receive message from Terminal and generate messages to be sent back to Terminal. The output of this project is *PSLMPEG2MessageInterface.lib*.

Note, this project is the same as the message projects introduced above. Any changes to either project must be synchronised.

- *DummyTool.dsp* in the same directory.


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This project contains the message related codes of an IPMP Tool. The dummy tool is also capable of accepting media streams from message router and returns the same packet without any processing. It can be easily extended to perform watermarking or encryption processing. The output of this project is *DummyTool.dll*.

### 8.3.7 Running The Reference Software

Launch the Playwnd.exe to get the player ready to work and select the MPEG-2 IPMP stream to playback. The launched application looks like shown in Figure 3:

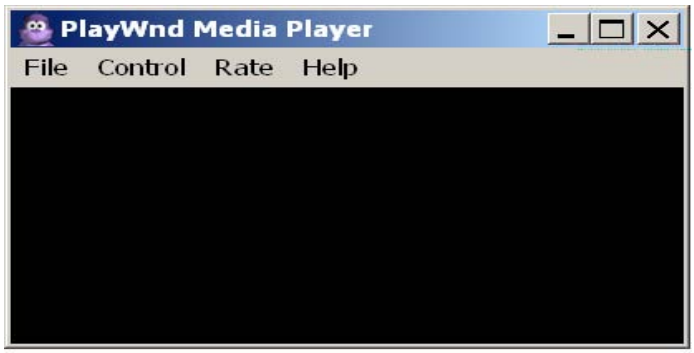


**Figure 3 — Terminal Window**

A possible scenario of an IPMP application could have the following architecture:

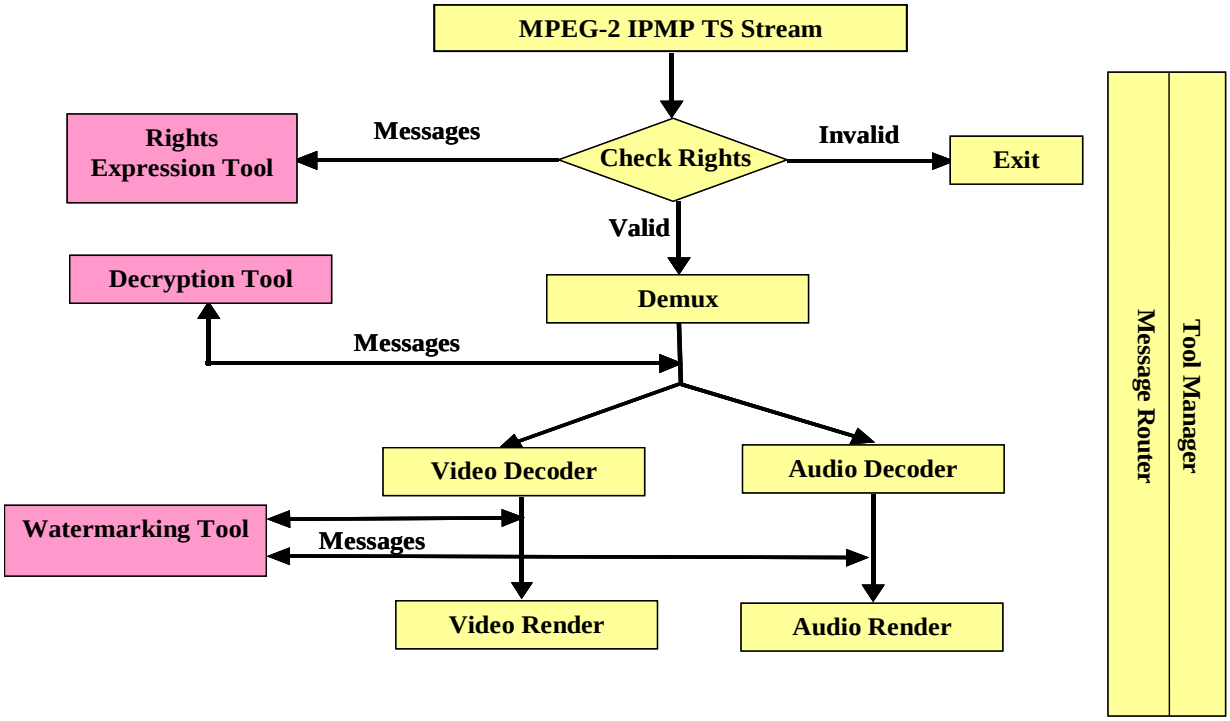


**Figure 4 — Architecture of an MPEG-2 IPMP Application**

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### 8.3.8 Source Code Repository

MPEG members can get the codes from MPEG CVS server: mpeg.nist.gov (password protected), in the directory MPEG-2\AMD2-IPMP. The codes are arranged in directory structure described by the following table.

Panasonic is in charge of the codes maintenance. Interested users can contact Shen Shengmei (shen@psl.com.sg) directly to get the latest version.

| Directory Name | Description |
|---|---|
| IPMP_TSMultiplexer | Directory of workspace ***Tsmuxer*** |
| IPMP_MainCodes | Directory of workspace ***MPEG2SplitterFilter*** |
| IPMPTool_DES | Directory of workspace ***DESDll*** |
| IPMPTool_REL | Directory of workspace ***RELTool*** |
| IPMPTool_Dummy | Directory of workspace ***DummyTool*** |


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# Annex A
(normative)

# Electronic annex containing software

This technical report contains C source code for Systems (systems.zip), IPMP (ipmp.zip), Video (video.zip), and Audio (mpeg2audio.zip, mpeg2aac.zip).

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# Annex B
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# List of patent holders

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**Table B-1 – Companies who supplied patent statements**

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| France Telecom S.A. |
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