(12) UK Patent (19) GB (11) 2593224 (13) B

(45) Date of B Publication 17.07.2024

(54) Title of the Invention: High level syntax for video coding and decoding

(51) INT CL: ***H04N 19/70*** (2014.01) ***H04N 19/119*** (2014.01) ***H04N 19/167*** (2014.01) ***H04N 19/172*** (2014.01) ***H04N 19/174*** (2014.01)

(21) Application No: **2004099.4**

(22) Date of Filing: **20.03.2020**

(43) Date of A Publication **22.09.2021**

(56) Documents Cited:
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JVET MEETING, 2020, HENDRY (LGE), "AHG9/AHG12: A Summary of HLS contributions on tiles and slices"

(58) Field of Search:
As for published application 2593224 A viz:
INT CL **H04N**
updated as appropriate

Additional Fields
Other: **SEARCH-PATENT**

(72) Inventor(s):
Guillaume Laroche
Naël Ouedraogo
Patrice Onno

(73) Proprietor(s):
Canon Kabushiki Kaisha
30-2 Shimomaruko 3-chome, Ohta-ku, Tokyo 146-8501, Japan

(74) Agent and/or Address for Service:
Canon Europe Limited
European Intellectual Property Group, 4 Roundwood Avenue, Stockley Park, Uxbridge, Middlesex, UB11 1AF, United Kingdom

GB 2593224 B

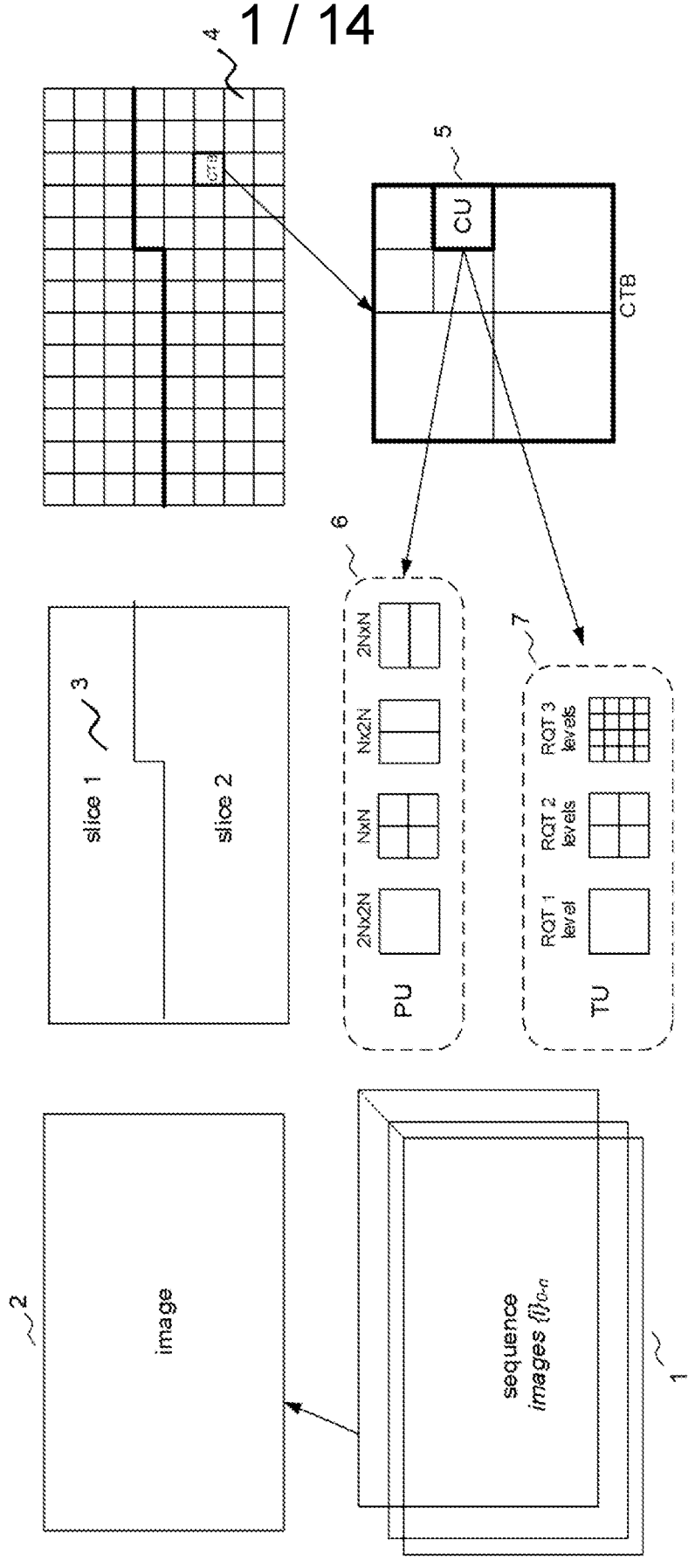

sequence
images {I}0-n
1
image
2
slice 1
slice 2
3
4
CTB
5
CU
CTB
6
PU
2Nx2N
NxN
Nx2N
2NxN
7
TU
RQT 1 level
RQT 2 levels
RQT 3 levels

Figure 1

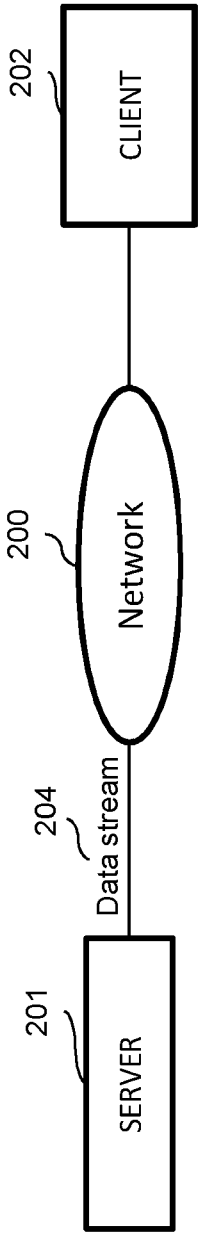


Figure 2

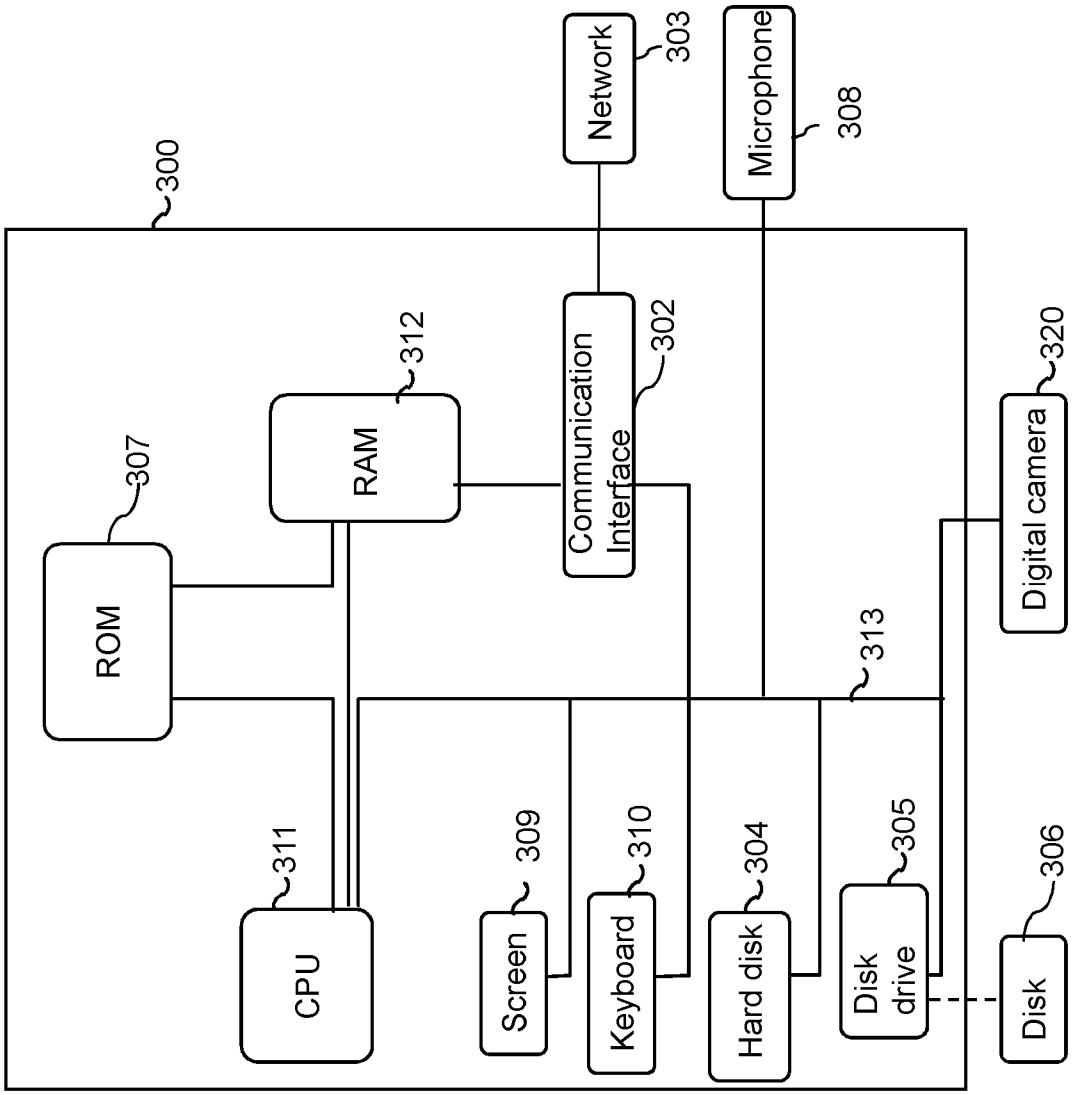

300
Network
303
Microphone
308
ROM
307
RAM
312
Communication Interface
302
Digital camera
320
313
CPU
311
Screen
309
Keyboard
310
Hard disk
304
Disk drive
305
Disk
306

Figure 3

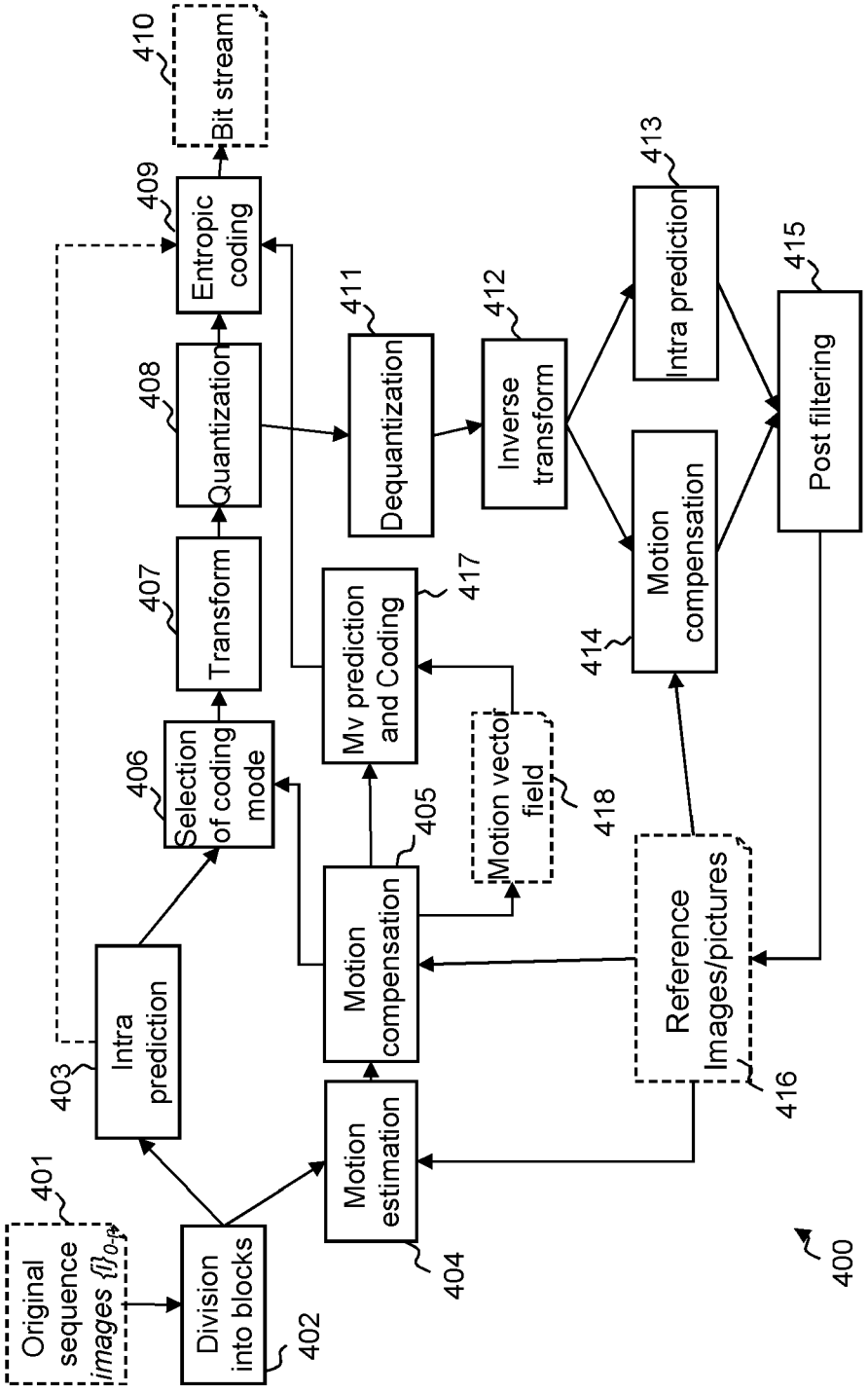

Original sequence images $\{I\}_{0<t}$
401
Division into blocks
402
Intra prediction
403
Motion estimation
404
Motion compensation
405
Selection of coding mode
406
Transform
407
Quantization
408
Entropic coding
409
Bit stream
410
Mv prediction and Coding
417
Motion vector field
418
Dequantization
411
Inverse transform
412
Intra prediction
413
Motion compensation
414
Post filtering
415
Reference Images/pictures
416
400

Figure 4

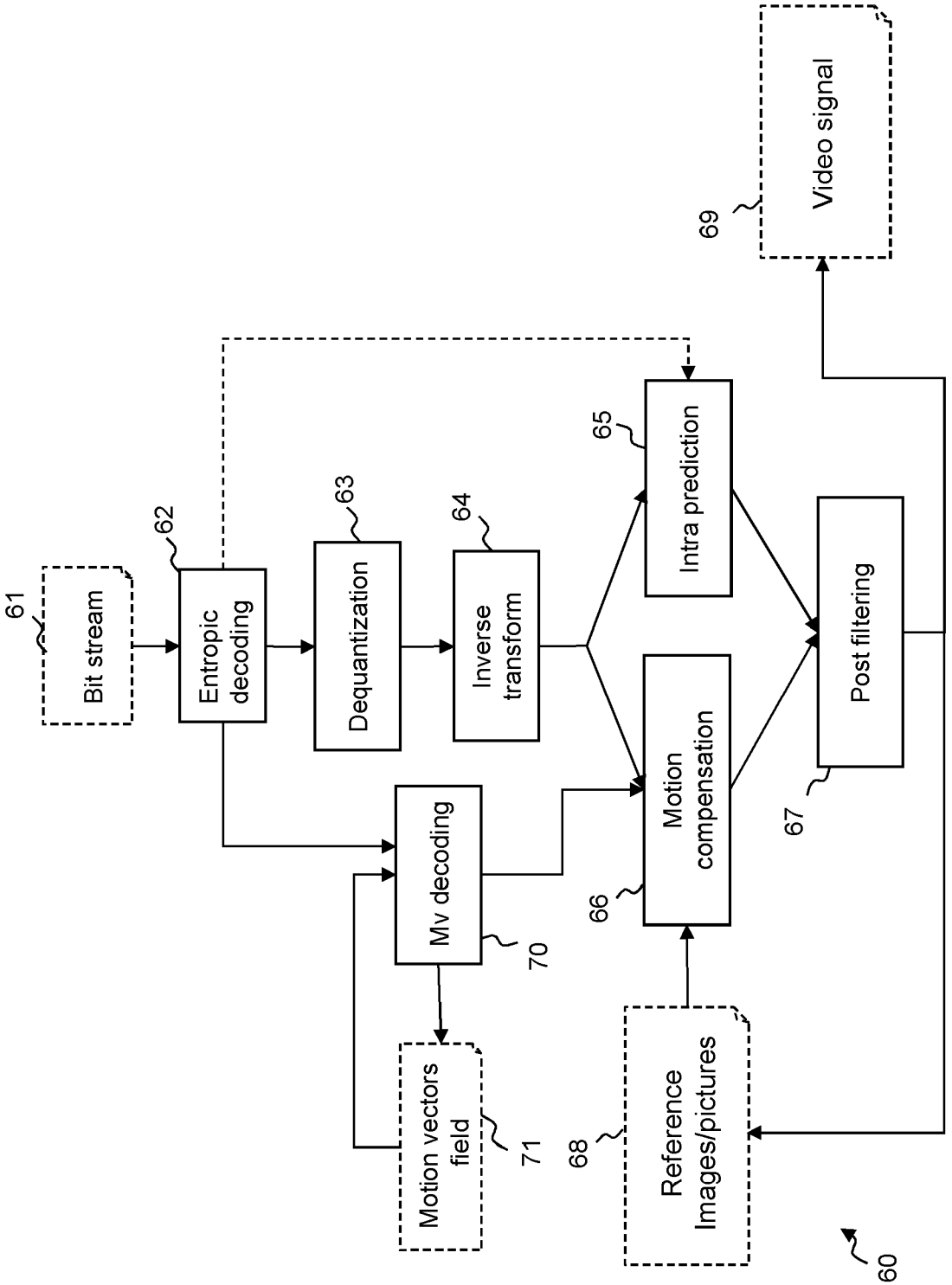

Bit stream
61
Entropic decoding
62
Dequantization
63
Inverse transform
64
Intra prediction
65
Motion compensation
66
Post filtering
67
Video signal
69
Mv decoding
70
Motion vectors field
71
Reference Images/pictures
68
60

Figure 5

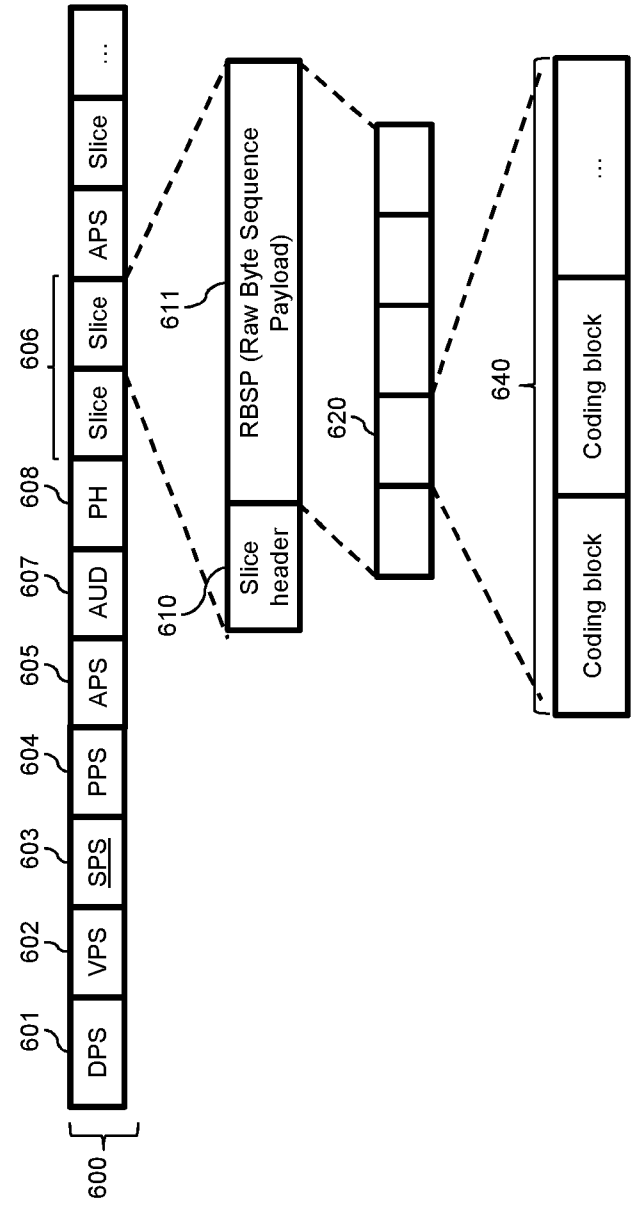

600
601
DPS
602
VPS
603
SPS
604
PPS
605
APS
607
AUD
608
PH
606
Slice
Slice
APS
Slice
...
610
Slice header
611
RBSP (Raw Byte Sequence Payload)
620
640
Coding block
Coding block
...

Figure 6

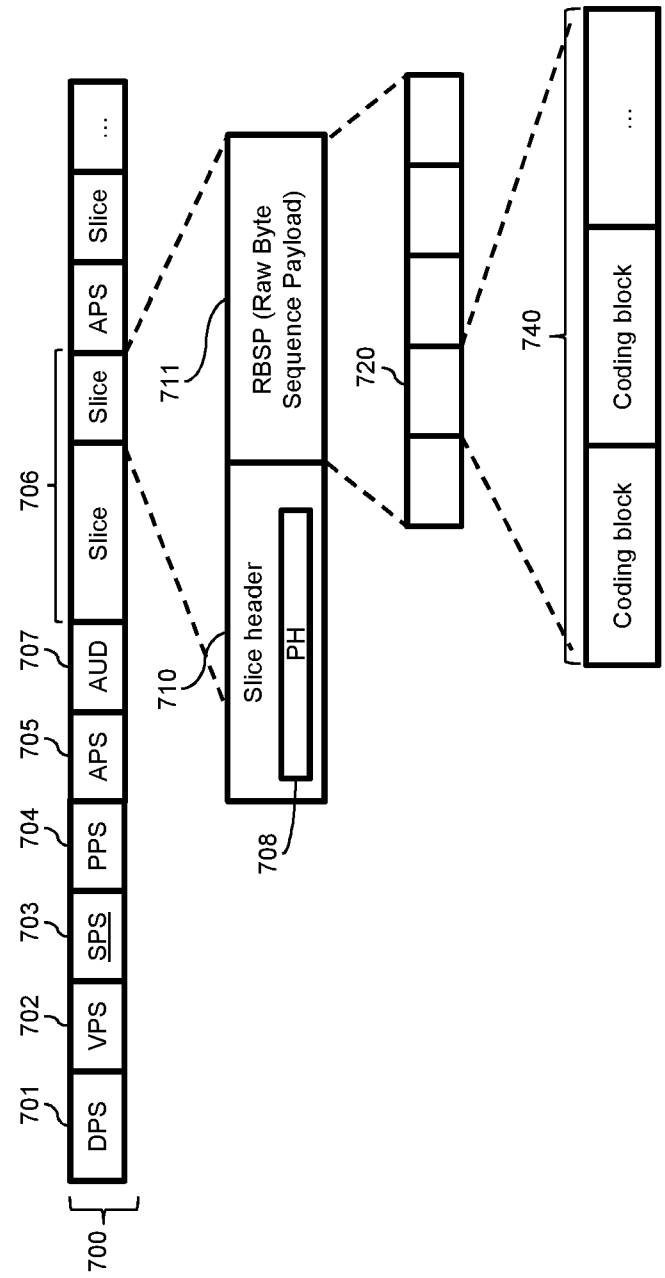

700
701
DPS
702
VPS
703
SPS
704
PPS
705
APS
707
AUD
706
Slice
Slice
APS
Slice
...
710
711
Slice header
PH
RBSP (Raw Byte Sequence Payload)
708
720
740
Coding block
Coding block
...

Figure 7

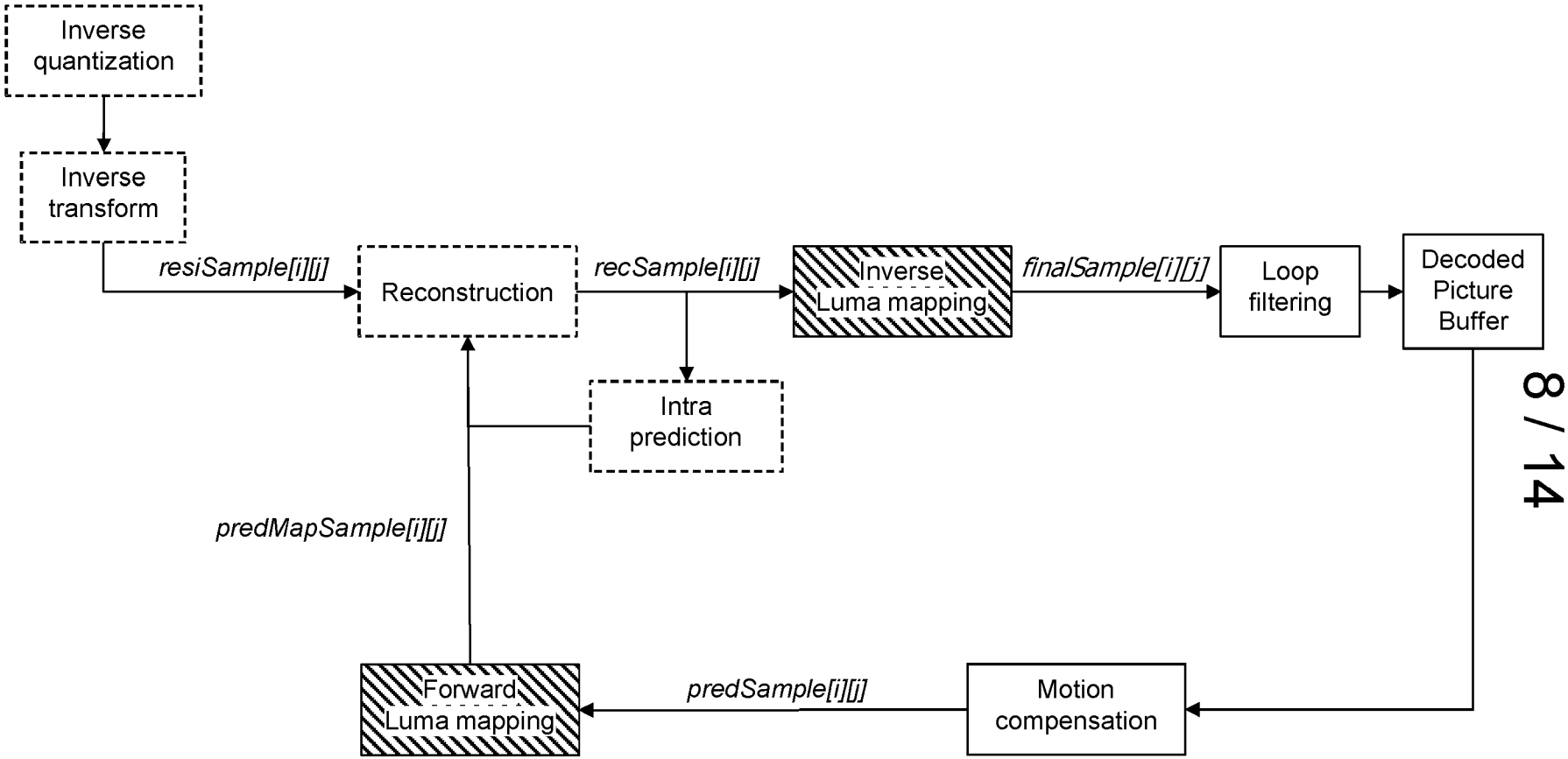

Inverse quantization
Inverse transform
resiSample[i][j]
Reconstruction
recSample[i][j]
Inverse Luma mapping
finalSample[i][j]
Loop filtering
Decoded Picture Buffer
Intra prediction
predMapSample[i][j]
Forward Luma mapping
predSample[i][j]
Motion compensation

Figure 8

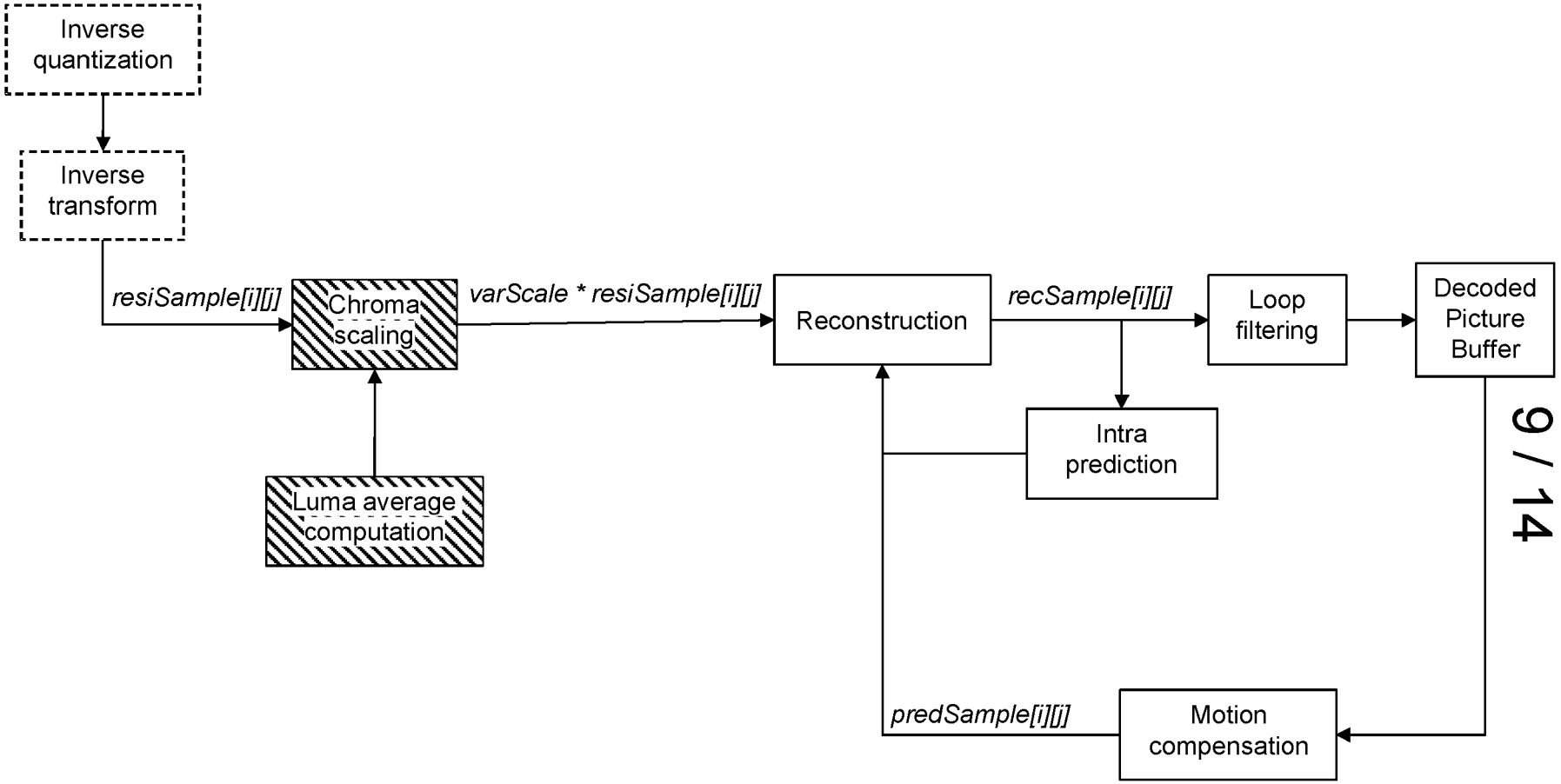
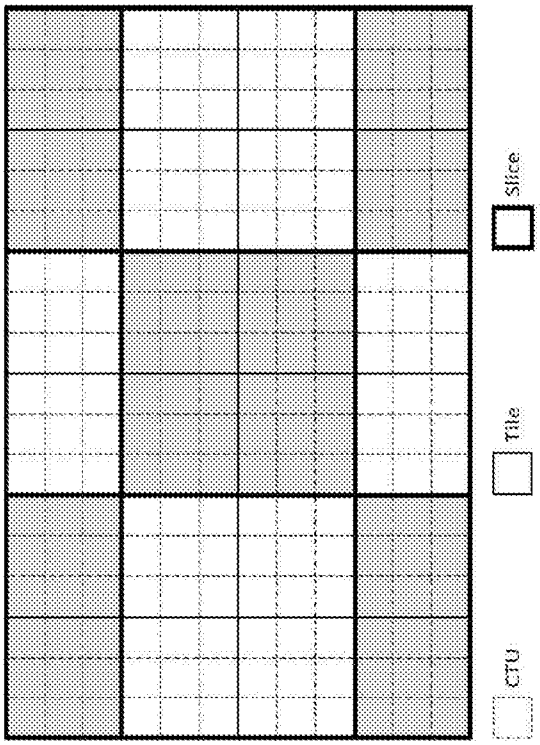
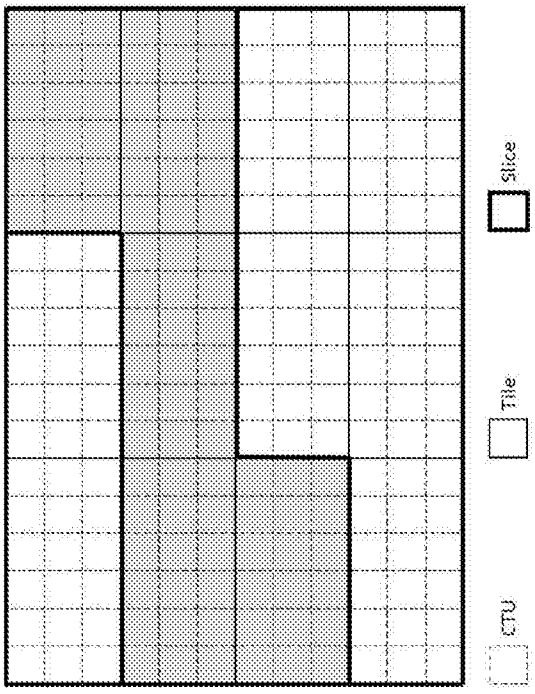

Inverse quantization
Inverse transform
resiSample[i][j]
Chroma scaling
varScale * resiSample[i][j]
Reconstruction
recSample[i][j]
Loop filtering
Decoded Picture Buffer
Intra prediction
Luma average computation
predSample[i][j]
Motion compensation

Figure 9



(b)



(a)

Figure 10

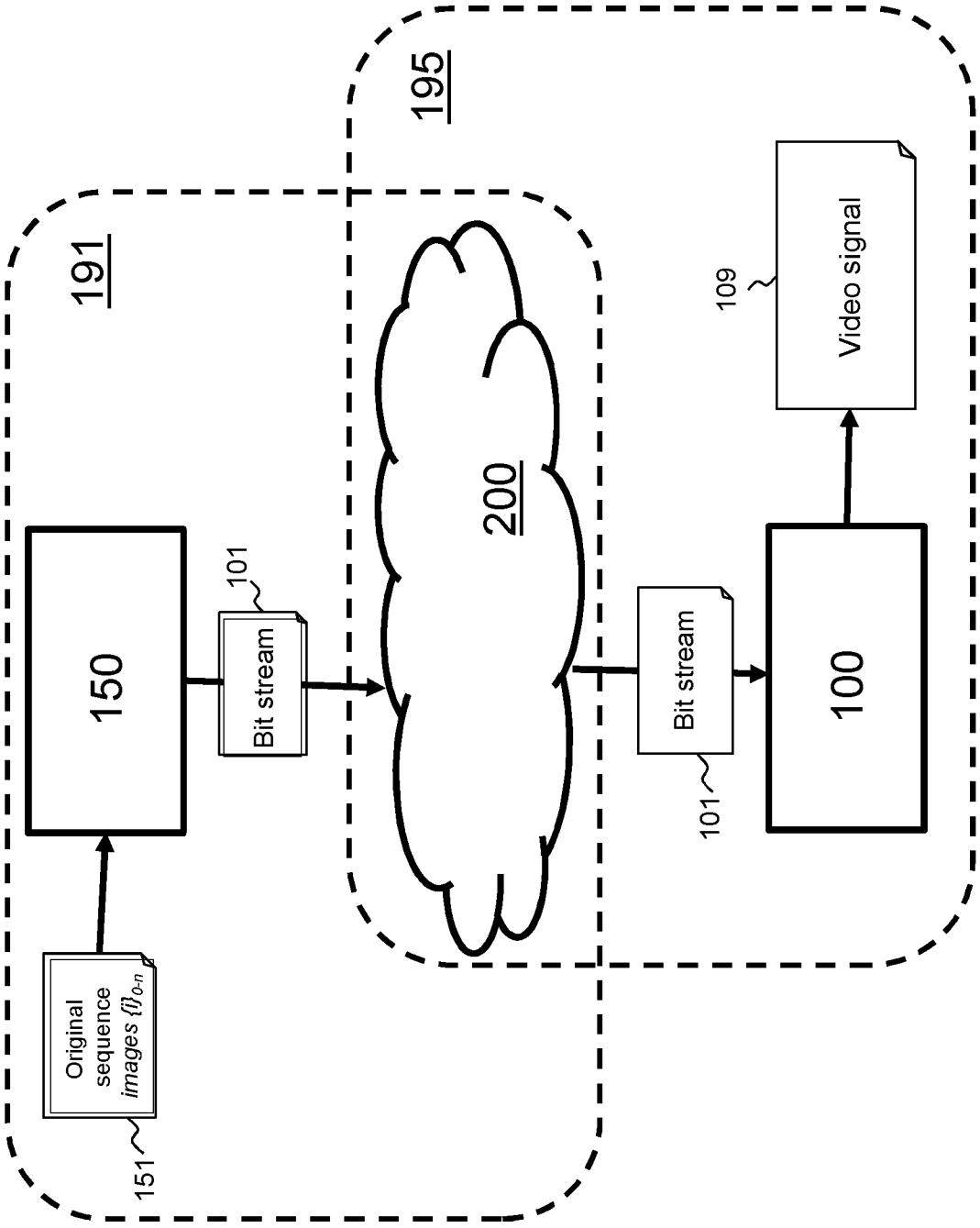

191
195
200
150
101
Bit stream
Original sequence images $\{I\}_{0-n}$
151
Bit stream
101
100
109
Video signal

Figure 11

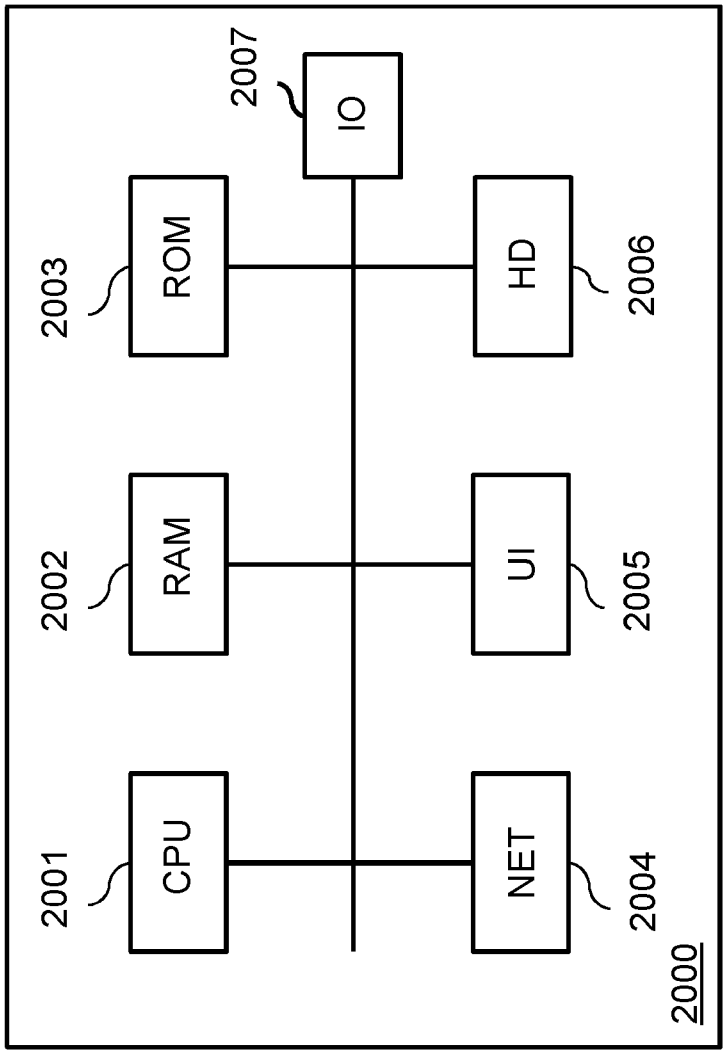

2007
IO
2003
ROM
HD
2006
2002
RAM
UI
2005
2001
CPU
NET
2004
2000

Figure 12

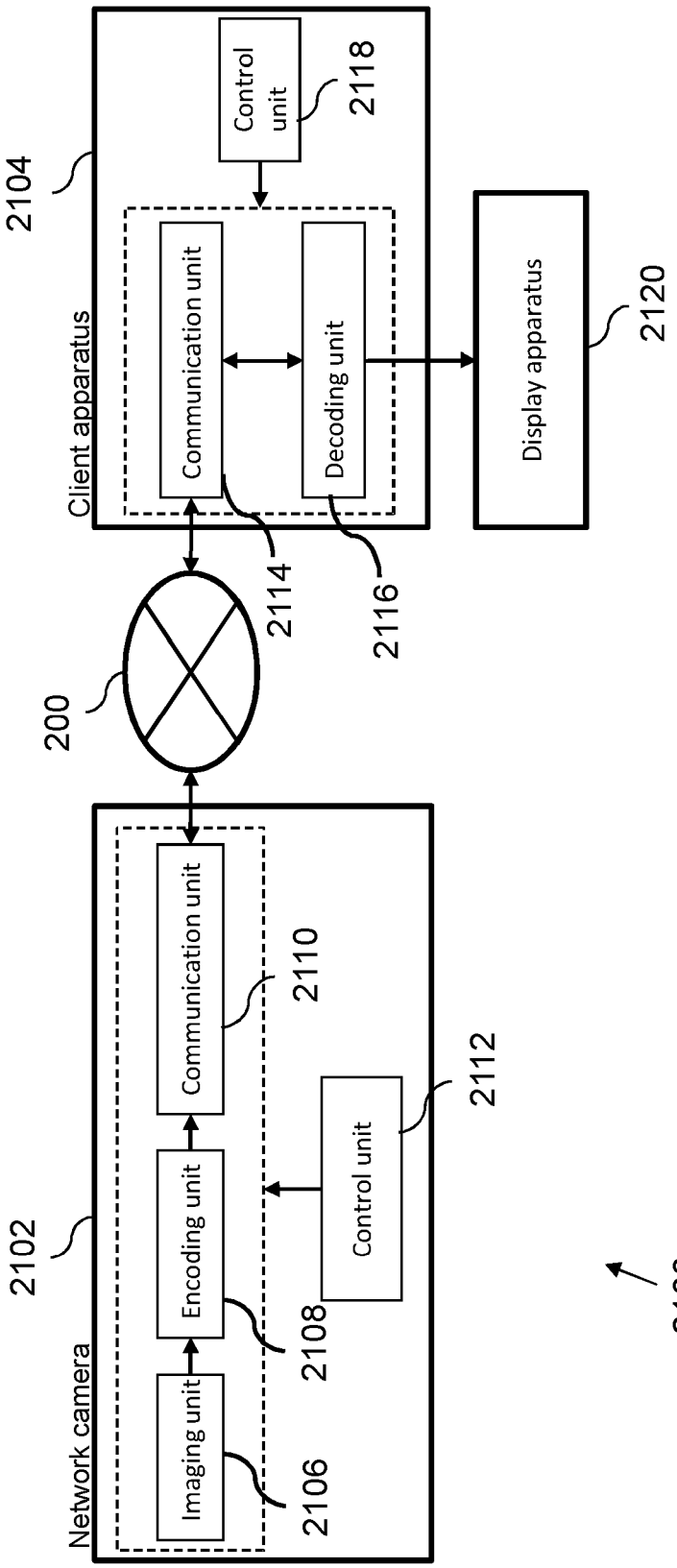

Network camera
2102
Imaging unit
2106
Encoding unit
2108
Communication unit
2110
Control unit
2112
200
Client apparatus
2104
Communication unit
2114
Decoding unit
2116
Control unit
2118
Display apparatus
2120
2100

Figure 13

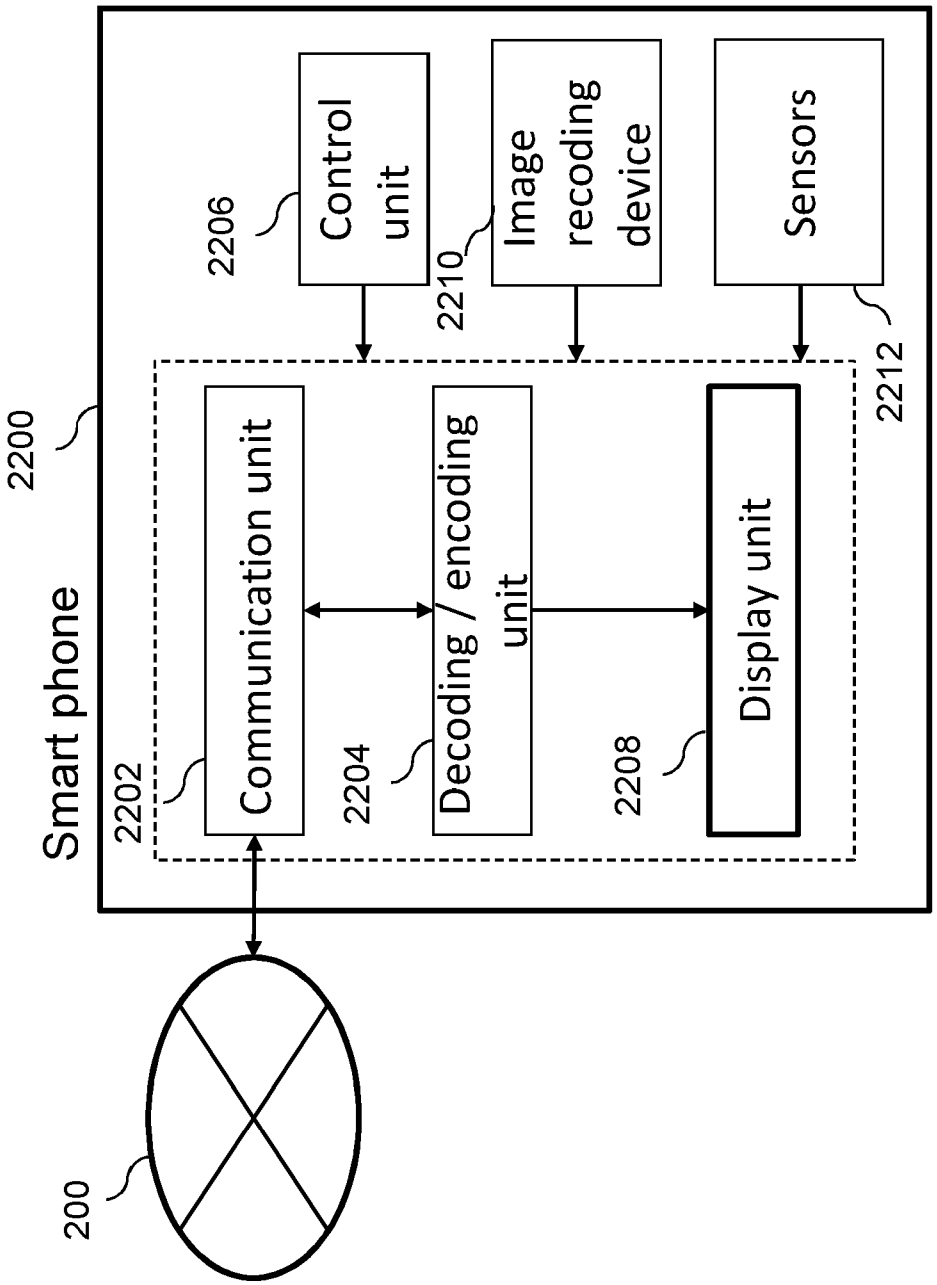

Smart phone
2200
Control unit
2206
Image recoding device
2210
Sensors
2212
Communication unit
2202
Decoding / encoding unit
2204
Display unit
2208
200

Figure 14

HIGH LEVEL SYNTAX FOR VIDEO CODING AND DECODING

Field of invention

The present invention relates to video coding and decoding, and in particular to the high level syntax used in the bitstream.

Background

Recently, the Joint Video Experts Team (JVET), a collaborative team formed by MPEG and ITU-T Study Group 16's VCEG, commenced work on a new video coding standard referred to as Versatile Video Coding (VVC). The goal of VVC is to provide significant improvements in compression performance over the existing HEVC standard (i.e., typically twice as much as before) and to be completed in 2020. The main target applications and services include — but not limited to — 360-degree and high-dynamic-range (HDR) videos. In total, JVET evaluated responses from 32 organizations using formal subjective tests conducted by independent test labs. Some proposals demonstrated compression efficiency gains of typically 40% or more when compared to using HEVC. Particular effectiveness was shown on ultra-high definition (UHD) video test material. Thus, we may expect compression efficiency gains well-beyond the targeted 50% for the final standard.

The JVET exploration model (JEM) uses all the HEVC tools and has introduced a number of new tools. These changes have necessitated a change to the structure of the bitstream, and in particular to the high-level syntax which can have a impact on the overall bitrate of the bitstream.

Summary

The present invention relates to an improvement to the high level syntax structure, which leads to a reduction in complexity without any degradation in coding performance.

In a first aspect according to the present invention, there is provided a method of decoding video data from a bitstream, the bitstream comprising video data corresponding to one or more slices, wherein each slice may include one or more tiles, wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when decoding a slice, comprises parsing the syntax elements, and in a case where a slice includes multiple tiles, omitting the parsing of a syntax element indicating an address of a slice if a syntax element is

parsed that indicates that a picture header is signalled in the slice header; and decoding said bitstream using said syntax elements.

Accordingly, the slice address is not parsed when the picture header is in the slice header which reduces the bitrate, especially for low delay and low bitrate applications. Further, the parsing complexity may be reduced when the picture is signalled in the slice header

In an embodiment, the omitting is to be performed (only) when a raster-scan slice mode is to be used for decoding the slice. This reduces the parsing complexity but still allows for some bitrate reduction.

The omitting may further comprise omitting the parsing of a syntax element indicating a number of tiles in the slice. Thus, a further reduction in bitrate may be achieved.

In a second aspect, there is provided a method of decoding video data from a bitstream, the bitstream comprising video data corresponding to one or more slices, wherein each slice may include one or more tiles, wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when decoding a slice, and the decoding comprises: parsing one or more syntax elements, and in a case where a slice includes multiple tiles, omitting the parsing of a syntax element indicating a number of tiles in the slice if a syntax element is parsed that indicates that the picture header is signalled in the slice header; and decoding said bitstream using said syntax elements. Thus, the bitrate may be reduced, which is advantageous especially for low delay and low bitrate applications where the number of tiles does not need to be transmitted.

The omitting may be performed (only) when a raster-scan slice mode is to be used for decoding the slice. This reduces the parsing complexity but still allows for some bitrate reduction.

The method may further comprise parsing syntax elements indicating a number of tiles in the picture and determining a number of tiles in the slice based on the number of tiles in the picture indicated by the parsed syntax elements. This is advantageous as it allows the number of tiles in the slice to be easily predicted in the case where a picture header is signalled in the slice header without requiring further signalling.

The omitting may further comprise omitting the parsing of a syntax element indicating an address of a slice. Thus, the bitrate may be further reduced.

In a third aspect of the present invention, there is provided a method of decoding video data from a bitstream, the bitstream comprising video data corresponding to one or more slices, wherein each slice may include one or more tiles, wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when decoding a slice, and the decoding comprises: parsing one or more syntax elements, and in a case where a slice includes multiple tiles, omitting the parsing of a syntax element indicating a slice address if a number of tiles in the slice is equal to a number of tiles in the picture; and decoding said bitstream using said syntax elements. This takes advantage of the insight that, if the number of tiles in the slice is equal to the number of tiles in the picture it is sure that the current picture contains only one slice. Accordingly, by omitting the slice address the bitrate can be improved and complexity in parsing and/or encoding reduced.

The omitting may be performed (only) when a raster-scan slice mode is to be used for decoding the slice. Thus, complexity may be reduced while still providing some bitrate reduction.

The decoding may further comprise parsing, in a slice, a syntax element indicating the number of tiles in the slice; and parsing, in a picture parameter set, syntax elements indicating the number of tiles in the picture, wherein the omitting of the parsing of the syntax element indicating the slice address is based on the parsed syntax elements.

The decoding may further comprise parsing the syntax element in the slice, indicating the number of tiles in the slice, prior to one or more syntax elements for signalling a slice address.

The decoding may further comprise parsing, in a slice, a syntax element indicating if a picture header is signalled in a slice header and determining (inferring) that the number of tiles in the slice is equal to the number of tiles in the picture if the parsed syntax element indicates that the picture header is signalled in the slice header.

In a fourth aspect there is provided a method of decoding video data from a bitstream, the bitstream comprising video data corresponding to one or more slices, wherein each slice may include one or more tiles, wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when decoding a slice, and the decoding comprises: parsing one or more syntax elements, and in a case where a syntax element indicates that a raster-scan decoding mode is enabled for a slice, decoding at least one of a slice address and a number of tiles in the slice from the one or more syntax elements, wherein the decoding of the at least one

of the slice address and the number of tiles in the slice from the one or more syntax elements in the case that the raster-scan decoding mode is enabled for the slice, does not depend on the number of tiles in the picture; and decoding said bitstream using said syntax elements. Thus, the parsing complexity of the slice header may be reduced.

In a fifth aspect according to the present invention, a method comprising the first and second aspects is provided.

In a sixth aspect according to the present invention, a method comprising the first and second and third aspects is provided.

According to a seventh aspect of the present invention, there is provided a method of encoding video data into a bitstream, the bitstream comprising the video data corresponding to one or more slices, wherein each slice may include one or more tiles, wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when encoding a slice, and the encoding comprises: determining one or more syntax elements for encoding the video data, and in a case where a slice includes multiple tiles, omitting the encoding of a syntax element indicating an address of a slice if a syntax element indicates that a picture header is signalled in the slice header; and encoding said video data using said syntax elements.

In one or more embodiments, the omitting is to be performed (only) when a raster-scan slice mode is used for encoding the slice.

The omitting may further comprise omitting the encoding of a syntax element indicating a number of tiles in the slice.

According to an eighth aspect of the present invention, there is provided a method of encoding video data into a bitstream, the bitstream comprising video data corresponding to one or more slices, wherein each slice may include one or more tiles, wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when decoding a slice, and the encoding comprises: determining one or more syntax elements for encoding the video data, and in a case where a slice includes multiple tiles, omitting the encoding of a syntax element indicating a number of tiles in the slice if a syntax element is determined for encoding that indicates that the picture header is signalled in the slice header; and encoding said video data using said syntax elements.

In an embodiment, the omitting is to be performed (only) when a raster-scan slice mode is to be used for encoding the slice.

The encoding may further comprise encoding syntax elements indicating a number of tiles in the picture, wherein a number of tiles in the slice is based on the number of tiles in the picture indicated by the parsed syntax elements.

The omitting may further comprise omitting the encoding of a syntax element indicating an address of a slice.

According to a ninth aspect of the present invention, there is provided a method of encoding video data into a bitstream, the bitstream comprising video data corresponding to one or more slices, wherein each slice may include one or more tiles, wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when decoding a slice, and the encoding comprises: determining one or more syntax elements, and in a case where a slice includes multiple tiles, omitting the encoding of a syntax element indicating a slice address if a number of tiles in the slice is equal to a number of tiles in the picture; and encoding said video data using said syntax elements.

In one or more embodiments, the omitting is to be performed (only) when a raster-scan slice mode is to be used for encoding the slice.

The encoding may further comprise encoding, in a slice, a syntax element indicating the number of tiles in the slice; and encoding, in a picture parameter set, syntax elements indicating the number of tiles in the picture, wherein the omitting or not of the encoding of the syntax element indicating the slice address is based on the value of the encoded syntax elements.

The encoding may further comprise encoding the syntax element in the slice, indicating the number of tiles in the slice, prior to one or more syntax elements for signalling a slice address.

The encoding may further comprise encoding, in a slice, a syntax element indicating if a picture header is signalled in a slice header, and determining that the number of tiles in the slice is equal to the number of tiles in the picture if the syntax element to be encoded indicates that the picture header is signalled in the slice header.

According to a tenth aspect of the present invention, there is provided a method of encoding video data into a bitstream, the bitstream comprising video data corresponding to one or more slices, wherein each slice may include one or more tiles, wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when decoding a slice, and the encoding comprises: determining one or more syntax elements for encoding the video data, and in a case where a syntax element determined for the encoding indicates that a raster-scan

decoding mode is enabled for a slice, encoding syntax elements indicating at least one of a slice address and a number of tiles in the slice, wherein the encoding of the at least one of the slice address and the number of tiles in the slice from the one or more syntax elements in the case that the raster-scan decoding mode is enabled for the slice, does not depend on the number of tiles in the picture; and decoding said bitstream using said syntax elements.

In a eleventh aspect according to the present invention, a method comprising the seventh and eighth aspects is provided.

In a twelfth aspect according to the present invention, a method comprising the seventh and eighth and ninth aspects is provided.

According to a thirteenth aspect of the present invention, there is provided a decoder for decoding video data from a bitstream, the decoder being configured to perform the method of any of the first to sixth aspects.

According to a fourteenth aspect of the present invention, there is provided an encoder for encoding video data into a bitstream, the encoder being configured to perform the method of any of the seventh to twelfth aspects.

According to a fifteenth aspect of the invention, there is provided a computer program which upon execution causes the method of any of the first to twelfth aspects to be performed. The program may be provided on its own or may be carried on, by or in a carrier medium. The carrier medium may be non-transitory, for example a storage medium, in particular a computer-readable storage medium. The carrier medium may also be transitory, for example a signal or other transmission medium. The signal may be transmitted via any suitable network, including the Internet. Further features of the invention are characterised by the independent and dependent claims

Any feature in one aspect of the invention may be applied to other aspects of the invention, in any appropriate combination. In particular, method aspects may be applied to apparatus aspects, and vice versa.

Furthermore, features implemented in hardware may be implemented in software, and vice versa. Any reference to software and hardware features herein should be construed accordingly

Any apparatus feature as described herein may also be provided as a method feature, and vice versa. As used herein, means plus function features may be expressed alternatively in terms of their corresponding structure, such as a suitably programmed processor and associated memory.

It should also be appreciated that particular combinations of the various features described and defined in any aspects of the invention can be implemented and/or supplied and/or used independently.

Brief Description of the Drawings

Reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a diagram for use in explaining a coding structure used in HEVC and VVC;

Figure 2 is a block diagram schematically illustrating a data communication system in which one or more embodiments of the invention may be implemented;

Figure 3 is a block diagram illustrating components of a processing device in which one or more embodiments of the invention may be implemented;

Figure 4 is a flow chart illustrating steps of an encoding method according to embodiments of the invention;

Figure 5 is a flow chart illustrating steps of a decoding method according to embodiments of the invention;

Figure 6 illustrates the structure of the bitstream in the exemplary coding system VVC

Figure 7 illustrates another structure of the bitstream in the exemplary coding system VVC;

Figure 8 illustrates Luma Modelling Chroma Scaling (LMCS);

Figure 9 shows a sub tool of LMCS;

Figure 10 is the illustration of the raster-scan slice mode and the rectangular slice mode of the current VVC draft standard;

Figure 11 is a diagram showing a system comprising an encoder or a decoder and a communication network according to embodiments of the present invention;

Figure 12 is a schematic block diagram of a computing device for implementation of one or more embodiments of the invention;

Figure 13 is a diagram illustrating a network camera system; and

Figure 14 is a diagram illustrating a smart phone.

Detailed description

Figure 1 relates to a coding structure used in the High Efficiency Video Coding (HEVC) video standard. A video sequence 1 is made up of a succession of digital images i. Each such digital image is represented by one or more matrices. The matrix coefficients represent pixels.

An image 2 of the sequence may be divided into slices 3. A slice may in some instances constitute an entire image. These slices are divided into non-overlapping Coding Tree Units (CTUs). A Coding Tree Unit (CTU) is the basic processing unit of the High Efficiency Video Coding (HEVC) video standard and conceptually corresponds in structure to macroblock units that were used in several previous video standards. A CTU is also sometimes referred to as a Largest Coding Unit (LCU). A CTU has luma and chroma component parts, each of which component parts is called a Coding Tree Block (CTB). These different color components are not shown in **Figure 1**.

A CTU is generally of size 64 pixels x 64 pixels. Each CTU may in turn be iteratively divided into smaller variable-size Coding Units (CUs) 5 using a quadtree decomposition.

Coding units are the elementary coding elements and are constituted by two kinds of sub-unit called a Prediction Unit (PU) and a Transform Unit (TU). The maximum size of a PU or TU is equal to the CU size. A Prediction Unit corresponds to the partition of the CU for prediction of pixels values. Various different partitions of a CU into PUs are possible as shown by 606 including a partition into 4 square PUs and two different partitions into 2 rectangular PUs. A Transform Unit is an elementary unit that is subjected to spatial transformation using DCT. A CU can be partitioned into TUs based on a quadtree representation 607.

Each slice is embedded in one Network Abstraction Layer (NAL) unit. In addition, the coding parameters of the video sequence are stored in dedicated NAL units called parameter sets. In HEVC and H.264/AVC two kinds of parameter sets NAL units are employed: first, a Sequence Parameter Set (SPS) NAL unit that gathers all parameters that are unchanged during the whole video sequence. Typically, it handles the coding profile, the size of the video frames and other parameters. Secondly, a Picture Parameter Set (PPS) NAL unit includes parameters that may change from one image (or frame) to another of a sequence. HEVC also includes a Video Parameter Set (VPS) NAL unit which contains parameters describing the overall structure of the bitstream. The VPS is a new type of parameter set defined in HEVC, and applies to all of the layers of a bitstream. A layer may contain multiple temporal sub-layers, and all version 1 bitstreams are restricted to a single layer. HEVC has certain layered extensions for scalability and multiview and these will enable multiple layers, with a backwards compatible version 1 base layer.

In the current definition of the Versatile Video Coding (VVC), there is three high level possibilities for the partitioning of a picture: subpictures, slices and tiles. Each having their own characteristics and usefulness. The partitioning into subpictures is for the spatial extraction and/or merging of regions of a video. The partitioning into slices is based on a similar concept

as the previous standards and corresponds to packetization for video transmission even if it can be used for other applications. The partitioning into Tiles is conceptually an encoder parallelisation tool as it splits the picture into independent coding regions of the same size (almost) of the picture. But this tool can be used also for other applications.

As these three high level available possible ways of partitioning of a picture can be used together, there is several modes for their usage. As defined in the current draft specifications of VVC, two modes of slices are defined. For the raster-scan slice mode, a slice contains a sequence of complete tiles in a tile raster scan of the picture. This mode in the current VVC specification is illustrated in **Figure 10(a)**. As shown in this figure, the picture contains 18 by 12 luma CTUs is shown that is partitioned into 12 tiles and 3 raster-scan slices.

For the second one, the rectangular slice mode, a slice contains either a number of complete tiles that collectively from a rectangular region of the picture. This mode in the current VVC specification is illustrated in **Figure 10(b)**. In this example, a picture with 18 by 12 luma CTUs is shown that is partitioned into 24 tiles and 9 rectangular slices.

Figure 2 illustrates a data communication system in which one or more embodiments of the invention may be implemented. The data communication system comprises a transmission device, in this case a server 201, which is operable to transmit data packets of a data stream to a receiving device, in this case a client terminal 202, via a data communication network 200. The data communication network 200 may be a Wide Area Network (WAN) or a Local Area Network (LAN). Such a network may be for example a wireless network (Wifi / 802.11a or b or g), an Ethernet network, an Internet network or a mixed network composed of several different networks. In a particular embodiment of the invention the data communication system may be a digital television broadcast system in which the server 201 sends the same data content to multiple clients.

The data stream 204 provided by the server 201 may be composed of multimedia data representing video and audio data. Audio and video data streams may, in some embodiments of the invention, be captured by the server 201 using a microphone and a camera respectively. In some embodiments data streams may be stored on the server 201 or received by the server 201 from another data provider, or generated at the server 201. The server 201 is provided with an encoder for encoding video and audio streams in particular to provide a compressed bitstream for transmission that is a more compact representation of the data presented as input to the encoder.

In order to obtain a better ratio of the quality of transmitted data to quantity of transmitted data, the compression of the video data may be for example in accordance with the HEVC format or H.264/AVC format.

The client 202 receives the transmitted bitstream and decodes the reconstructed bitstream to reproduce video images on a display device and the audio data by a loud speaker.

Although a streaming scenario is considered in the example of **Figure 2**, it will be appreciated that in some embodiments of the invention the data communication between an encoder and a decoder may be performed using for example a media storage device such as an optical disc.

In one or more embodiments of the invention a video image is transmitted with data representative of compensation offsets for application to reconstructed pixels of the image to provide filtered pixels in a final image.

Figure 3 schematically illustrates a processing device 300 configured to implement at least one embodiment of the present invention. The processing device 300 may be a device such as a micro-computer, a workstation or a light portable device. The device 300 comprises a communication bus 313 connected to:

-a central processing unit 311, such as a microprocessor, denoted CPU;

-a read only memory 306, denoted ROM, for storing computer programs for implementing the invention;

-a random access memory 312, denoted RAM, for storing the executable code of the method of embodiments of the invention as well as the registers adapted to record variables and parameters necessary for implementing the method of encoding a sequence of digital images and/or the method of decoding a bitstream according to embodiments of the invention; and

-a communication interface 302 connected to a communication network 303 over which digital data to be processed are transmitted or received

Optionally, the apparatus 300 may also include the following components:

-a data storage means 304 such as a hard disk, for storing computer programs for implementing methods of one or more embodiments of the invention and data used or produced during the implementation of one or more embodiments of the invention;

-a disk drive 305 for a disk 306, the disk drive being adapted to read data from the disk 306 or to write data onto said disk;

-a screen 309 for displaying data and/or serving as a graphical interface with the user, by means of a keyboard 310 or any other pointing means.

The apparatus 300 can be connected to various peripherals, such as for example a digital camera 320 or a microphone 308, each being connected to an input/output card (not shown) so as to supply multimedia data to the apparatus 300.

The communication bus provides communication and interoperability between the various elements included in the apparatus 300 or connected to it. The representation of the bus is not limiting and in particular the central processing unit is operable to communicate instructions to any element of the apparatus 300 directly or by means of another element of the apparatus 300.

The disk 306 can be replaced by any information medium such as for example a compact disk (CD-ROM), rewritable or not, a ZIP disk or a memory card and, in general terms, by an information storage means that can be read by a microcomputer or by a microprocessor, integrated or not into the apparatus, possibly removable and adapted to store one or more programs whose execution enables the method of encoding a sequence of digital images and/or the method of decoding a bitstream according to the invention to be implemented.

The executable code may be stored either in read only memory 306, on the hard disk 304 or on a removable digital medium such as for example a disk 306 as described previously. According to a variant, the executable code of the programs can be received by means of the communication network 303, via the interface 302, in order to be stored in one of the storage means of the apparatus 300 before being executed, such as the hard disk 304.

The central processing unit 311 is adapted to control and direct the execution of the instructions or portions of software code of the program or programs according to the invention, instructions that are stored in one of the aforementioned storage means. On powering up, the program or programs that are stored in a non-volatile memory, for example on the hard disk 304 or in the read only memory 306, are transferred into the random access memory 312, which then contains the executable code of the program or programs, as well as registers for storing the variables and parameters necessary for implementing the invention.

In this embodiment, the apparatus is a programmable apparatus which uses software to implement the invention. However, alternatively, the present invention may be implemented in hardware (for example, in the form of an Application Specific Integrated Circuit or ASIC).

Figure 4 illustrates a block diagram of an encoder according to at least one embodiment of the invention. The encoder is represented by connected modules, each module being adapted to implement, for example in the form of programming instructions to be executed by the CPU 311 of device 300, at least one corresponding step of a method implementing at least one

embodiment of encoding an image of a sequence of images according to one or more embodiments of the invention.

An original sequence of digital images *i*0 to *i*n 401 is received as an input by the encoder 400. Each digital image is represented by a set of samples, known as pixels.

A bitstream 410 is output by the encoder 400 after implementation of the encoding process. The bitstream 410 comprises a plurality of encoding units or slices, each slice comprising a slice header for transmitting encoding values of encoding parameters used to encode the slice and a slice body, comprising encoded video data.

The input digital images *i*0 to *i*n 401 are divided into blocks of pixels by module 402. The blocks correspond to image portions and may be of variable sizes (e.g. 4x4, 8x8, 16x16, 32x32, 64x64, 128x128 pixels and several rectangular block sizes can be also considered). A coding mode is selected for each input block. Two families of coding modes are provided: coding modes based on spatial prediction coding (Intra prediction), and coding modes based on temporal prediction (Inter coding, Merge, SKIP). The possible coding modes are tested.

Module 403 implements an Intra prediction process, in which the given block to be encoded is predicted by a predictor computed from pixels of the neighbourhood of said block to be encoded. An indication of the selected Intra predictor and the difference between the given block and its predictor is encoded to provide a residual if the Intra coding is selected.

Temporal prediction is implemented by motion estimation module 404 and motion compensation module 405. Firstly, a reference image from among a set of reference images 416 is selected, and a portion of the reference image, also called reference area or image portion, which is the closest area to the given block to be encoded, is selected by the motion estimation module 404. Motion compensation module 405 then predicts the block to be encoded using the selected area. The difference between the selected reference area and the given block, also called a residual block, is computed by the motion compensation module 405. The selected reference area is indicated by a motion vector.

Thus, in both cases (spatial and temporal prediction), a residual is computed by subtracting the prediction from the original block.

In the INTRA prediction implemented by module 403, a prediction direction is encoded. In the temporal prediction, at least one motion vector is encoded. In the Inter prediction implemented by modules 404, 405, 416, 418, 417, at least one motion vector or data for identifying such motion vector is encoded for the temporal prediction.

Information relative to the motion vector and the residual block is encoded if the Inter prediction is selected. To further reduce the bitrate, assuming that motion is homogeneous, the

motion vector is encoded by difference with respect to a motion vector predictor. Motion vector predictors of a set of motion information predictors is obtained from the motion vectors field 418 by a motion vector prediction and coding module 417.

The encoder 400 further comprises a selection module 406 for selection of the coding mode by applying an encoding cost criterion, such as a rate-distortion criterion. In order to further reduce redundancies a transform (such as DCT) is applied by transform module 407 to the residual block, the transformed data obtained is then quantized by quantization module 408 and entropy encoded by entropy encoding module 409. Finally, the encoded residual block of the current block being encoded is inserted into the bitstream 410.

The encoder 400 also performs decoding of the encoded image in order to produce a reference image for the motion estimation of the subsequent images. This enables the encoder and the decoder receiving the bitstream to have the same reference frames. The inverse quantization module 411 performs inverse quantization of the quantized data, followed by an inverse transform by reverse transform module 412. The reverse intra prediction module 413 uses the prediction information to determine which predictor to use for a given block and the reverse motion compensation module 414 actually adds the residual obtained by module 412 to the reference area obtained from the set of reference images 416.

Post filtering is then applied by module 415 to filter the reconstructed frame of pixels. In the embodiments of the invention an SAO loop filter is used in which compensation offsets are added to the pixel values of the reconstructed pixels of the reconstructed image

Figure 5 illustrates a block diagram of a decoder 60 which may be used to receive data from an encoder according an embodiment of the invention. The decoder is represented by connected modules, each module being adapted to implement, for example in the form of programming instructions to be executed by the CPU 311 of device 300, a corresponding step of a method implemented by the decoder 60.

The decoder 60 receives a bitstream 61 comprising encoding units, each one being composed of a header containing information on encoding parameters and a body containing the encoded video data. The structure of the bitstream in VVC is described in more detail below with reference to **Figure 6**. As explained with respect to **Figure 4**, the encoded video data is entropy encoded, and the motion vector predictors' indexes are encoded, for a given block, on a predetermined number of bits. The received encoded video data is entropy decoded by module 62. The residual data are then dequantized by module 63 and then a reverse transform is applied by module 64 to obtain pixel values.

The mode data indicating the coding mode are also entropy decoded and based on the mode, an INTRA type decoding or an INTER type decoding is performed on the encoded blocks of image data.

In the case of INTRA mode, an INTRA predictor is determined by intra reverse prediction module 65 based on the intra prediction mode specified in the bitstream.

If the mode is INTER, the motion prediction information is extracted from the bitstream so as to find the reference area used by the encoder. The motion prediction information is composed of the reference frame index and the motion vector residual. The motion vector predictor is added to the motion vector residual in order to obtain the motion vector by motion vector decoding module 70.

Motion vector decoding module 70 applies motion vector decoding for each current block encoded by motion prediction. Once an index of the motion vector predictor, for the current block has been obtained the actual value of the motion vector associated with the current block can be decoded and used to apply reverse motion compensation by module 66. The reference image portion indicated by the decoded motion vector is extracted from a reference image 68 to apply the reverse motion compensation 66. The motion vector field data 71 is updated with the decoded motion vector in order to be used for the inverse prediction of subsequent decoded motion vectors.

Finally, a decoded block is obtained. Post filtering is applied by post filtering module 67. A decoded video signal 69 is finally provided by the decoder 60.

Figure 6 illustrates the organisation of the bitstream in the exemplary coding system VVC as describe in JVET-Q2001-vD.

A bitstream **61** according to the VVC coding system is composed of an ordered sequence of syntax elements and coded data. The syntax elements and coded data are placed into Network Abstraction Layer (NAL) units **601-608**. There are different NAL unit types. The network abstraction layer provides the ability to encapsulate the bitstream into different protocols, like RTP/IP, standing for Real Time Protocol / Internet Protocol, ISO Base Media File Format, etc. The network abstraction layer also provides a framework for packet loss resilience.

NAL units are divided into Video Coding Layer (VCL) NAL units and non-VCL NAL units. The VCL NAL units contain the actual encoded video data. The non-VCL NAL units contain additional information. This additional information may be parameters needed for the decoding of the encoded video data or supplemental data that may enhance usability of the

decoded video data. NAL units **606** correspond to slices and constitute the VCL NAL units of the bitstream.

Different NAL units **601-605** correspond to different parameter sets, these NAL units are non-VCL NAL units. The Decoder Parameter Set (DPS) NAL unit 301contains parameters that are constant for a given decoding process. The Video Parameter Set (VPS) NAL unit **602** contains parameters defined for the whole video, and thus the whole bitstream. The DPS NAL unit may define parameters more static than the parameters in the VPS. In other words, the parameters of DPS change less frequently than the parameter of the VPS.

The Sequence Parameter Set (SPS) NAL unit **603** contains parameters defined for a video sequence. In particular, the SPS NAL unit may define the sub pictures layout and associated parameters of the video sequences. The parameters associated to each subpicture specifies the coding constraints applied to the subpicture. In particular, it comprises a flag indicating that the temporal prediction between subpictures is restricted to the data coming from the same subpicture. Another flag may enable or disable the loop filters across the subpicture boundaries.

The Picture Parameter Set (PPS) NAL unit **604**, PPS contains parameters defined for a picture or a group of pictures. The Adaptation Parameter Set (APS) NAL unit **605**, contains parameters for loop filters typically the Adaptive Loop Filter (ALF) or the reshaper model (or luma mapping with chroma scaling (LMCS) model) or the scaling matrices that are used at the slice level.

The syntax of the PPS as proposed in the current version of VVC comprises syntax elements that specifies the size of the picture in luma samples and also the partitioning of each picture in tiles and slices.

The PPS contains syntax elements that make it possible to determine the slices location in a frame. Since a subpicture forms a rectangular region in the frame, it is possible to determine the set of slices, the parts of tiles or the tiles that belong to a subpicture from the Parameter Sets NAL units. The PPS as with the APS have an ID mechanism to limit the amount of same PPS's transmitted.

The main difference between the PPS and Picture Header is it transmission, the PPS is generally transmitted for a group of pictures compared to the PH which is systematically transmitted for each Picture. Accordingly, the PPS compared to the PH contains parameters which can be constant for several picture.

The bitstream may also contain Supplemental Enhancement Information (SEI) NAL units (not represented in Figure 6). The periodicity of occurrence of these parameter sets in the

bitstream is variable. A VPS that is defined for the whole bitstream may occur only once in the bitstream. To the contrary, an APS that is defined for a slice may occur once for each slice in each picture. Actually, different slices may rely on the same APS and thus there are generally fewer APS than slices in each picture. In particular, the APS is defined in the picture header. Yet, the ALF APS can be refined in the slice header.

The Access Unit Delimiter (AUD) NAL unit **607** separates two access units. An access unit is a set of NAL units which may comprise one or more coded pictures with the same decoding timestamp. This optional NAL unit contains only one syntax element in current VVC specification: pic_type, this syntax element. indicates that the slice_type values for all slices of the coded pictures in the AU. If pic_type is set equal to 0, the AU contain only Intra slice. If equal to 1, it contains P and I slices. If equal to 2 it contains B, P or Intra slice

This NAL unit contains only one syntax element the pic-type.

Table 1 Syntax AUD

access_unit_delimiter_rbsp( ) {	**Descriptor**
pic_type	u(3)
rbsp_trailing_bits( )	
}	

In JVET-Q2001-vD the *pic_type* is defined as follow:

> "*pic_type* indicates that the *slice_type* values for all slices of the coded pictures in the AU containing the AU delimiter NAL unit are members of the set listed in Table 2 for the given value of *pic_type*. The value of *pic_type* shall be equal to 0, 1 or 2 in bitstreams conforming to this version of this Specification. Other values of *pic_type* are reserved for future use by ITU-T | ISO/IEC. Decoders conforming to this version of this Specification shall ignore reserved values of *pic_type*."

The rbsp_trailing_bits( ) is a function which adds bits in order to be aligned to the end of a byte. So after, this function, the amount of bitstream parsed is an integer number of bytes.

Table 2 Interpretation of *pic_type*

pic_type	**slice_type values that may be present in the AU**
0	I
1	P, I
2	B, P, I

The PH NAL unit **608** is the Picture Header NAL unit which groups parameters common to a set of slices of one coded picture. The picture may refer to one or more APS to indicate the AFL parameters, reshaper model and the scaling matrices used by the slices of the Picture.

Each of the VCL NAL units **606** contains a slice. A slice may correspond to the whole picture or sub picture, a single tile or a plurality of tiles or a fraction of a tile. For example the slice of the **Figure 3** contains several tiles **620**. A slice is composed of a slice header **610** and a raw byte sequence payload, RBSP **611** that contains the coded pixels data encoded as coded blocks **640**.

The syntax of the PPS as proposed in the current version of VVC comprises syntax elements that specifies the size of the picture in luma samples and also the partitioning of each picture in tiles and slices.

The PPS contains syntax elements that make it possible to determine the slices location in a frame. Since a subpicture forms a rectangular region in the frame, it is possible to determine the set of slices, the parts of tiles or the tiles that belong to a subpicture from the Parameter Sets NAL units.

NAL Unit Slice

The NAL unit slice layer contains the slice header and the slice data as illustrated in Table 3.

Table 3 Slice layer syntax

slice_layer_rbsp( ) {	**Descriptor**
slice_header( )	
slice_data( )	
rbsp_slice_trailing_bits( )	
}	

APS

The Adaptation Parameter Set (APS) NAL unit 60**5**, is defined in **Table 4** showing the syntax elements.

As depicted in table **Table 4**, there are 3 possible types of APS given by the aps_params_type syntax element:

- ALF_AP: for the ALF parameters
- LMCS_APS for the LMCS parameters
- SCALING_APS for Scaling list relative parameters

Table 4 Adaptation parameter set syntax

adaptation_parameter_set_rbsp( ) {	**Descriptor**
adaptation_parameter_set_id	u(5)
aps_params_type	u(3)
if(aps_params_type == ALF_APS)	
alf_data( )	
else if(aps_params_type == LMCS_APS)	
lmcs_data( )	
else if(aps_params_type == SCALING_APS)	
scaling_list_data( )	
aps_extension_flag	u(1)
if(aps_extension_flag)	
while(more_rbsp_data( ))	
aps_extension_data_flag	u(1)
rbsp_trailing_bits( )	
}	

These three types of APS parameters are discussed in turn below

ALF APS

The ALF parameters are described in Adaptive loop filter data syntax elements (Table 5). First, four flags are dedicated to specify whether or not the ALF filters are transmitted for Luma and/or for Chroma and if the CC-ALF (Cross Component Adaptive Loop Filtering) is enabled for Cb component and Cr component. If the Luma filter flag is enabled, another flag is decoded to know if the clip values are signalled (*alf_luma_clip_flag*). Then the number of filters signalled is decoded using the alf_luma_num_filters_signalled_minus1 syntax element. If needed, the syntax element representing the ALF coefficients delta "*alf_luma_coeff_delta_idx*" is decoded for each enabled filter. Then absolute value and the sign for each coefficient of each filter are decoded.

If the *alf_luma_clip_flag* is enabled, the clip index for each coefficient of each enabled filter is decoded.

In the same way, the ALF chroma coefficients are decoded if needed.

If CC-ALF is enabled for Cr or Cb the number of filter are decoded (*alf_cc_cb_filters_signalled_minus1or alf_cc_cr_filters_signalled_minus1*) and the related

coefficients are decoded (*alf_cc_cb_mapped_coeff_abs* and *alf_cc_cb_coeff_sign* or respectively *alf_cc_cr_mapped_coeff_abs* and *alf_cc_cr_coeff_sign*)

Table 5 Adaptive loop filter data syntax

alf_data( ) {	**Descriptor**
alf_luma_filter_signal_flag	u(1)
alf_chroma_filter_signal_flag	u(1)
alf_cc_cb_filter_signal_flag	u(1)
alf_cc_cr_filter_signal_flag	u(1)
if(alf_luma_filter_signal_flag) {	
alf_luma_clip_flag	u(1)
alf_luma_num_filters_signalled_minus1	ue(v)
if(alf_luma_num_filters_signalled_minus1 > 0)	
for(filtIdx = 0; filtIdx < NumAlfFilters; filtIdx++)	
alf_luma_coeff_delta_idx[filtIdx]	u(v)
for(sfIdx = 0; sfIdx <= alf_luma_num_filters_signalled_minus1; sfIdx++)	
for(j = 0; j < 12; j++) {	
alf_luma_coeff_abs[sfIdx][j]	ue(v)
if(alf_luma_coeff_abs[sfIdx][j])	
alf_luma_coeff_sign[sfIdx][j]	u(1)
}	
if(alf_luma_clip_flag)	
for(sfIdx = 0; sfIdx <= alf_luma_num_filters_signalled_minus1; sfIdx++)	
for(j = 0; j < 12; j++)	
alf_luma_clip_idx[sfIdx][j]	u(2)
}	
if(alf_chroma_filter_signal_flag) {	
alf_chroma_clip_flag	u(1)
alf_chroma_num_alt_filters_minus1	ue(v)
for(altIdx = 0; altIdx <= alf_chroma_num_alt_filters_minus1; altIdx++) {	
for(j = 0; j < 6; j++) {	
alf_chroma_coeff_abs[altIdx][j]	ue(v)
if(alf_chroma_coeff_abs[altIdx][j] > 0)	
alf_chroma_coeff_sign[altIdx][j]	u(1)
}	
if(alf_chroma_clip_flag)	
for(j = 0; j < 6; j++)	
alf_chroma_clip_idx[altIdx][j]	u(2)
}	
}	

if(alf_cc_cb_filter_signal_flag) {	
alf_cc_cb_filters_signalled_minus1	ue(v)
for(k = 0; k < alf_cc_cb_filters_signalled_minus1 + 1; k++) {	
for(j = 0; j < 7; j++) {	
alf_cc_cb_mapped_coeff_abs[k][j]	u(3)
if(alf_cc_cb_mapped_coeff_abs[k][j])	
alf_cc_cb_coeff_sign[k][j]	u(1)
}	
}	
}	
if(alf_cc_cr_filter_signal_flag) {	
alf_cc_cr_filters_signalled_minus1	ue(v)
for(k = 0; k < alf_cc_cr_filters_signalled_minus1 + 1; k++) {	
for(j = 0; j < 7; j++) {	
alf_cc_cr_mapped_coeff_abs[k][j]	u(3)
if(alf_cc_cr_mapped_coeff_abs[k][j])	
alf_cc_cr_coeff_sign[k][j]	u(1)
}	
}	
}	
}	

LMCS syntax elements for both Luma mapping and Chroma scaling

The Table 6 below gives all the LMCS syntax elements which are coded in the adaptation parameter set (APS) syntax structure when the aps_params_type parameter is set to 1 (LMCS_APS). Up to four LMCS APS's can be used in a coded video sequence, however, only a single LMCS APS can be used for a given picture.

These parameters are used to build the forward and inverse mapping functions for Luma and the scaling function for Chroma.

Table 6 Luma mapping with chroma scaling data syntax

lmcs_data () {	**Descriptor**
lmcs_min_bin_idx	ue(v)
lmcs_delta_max_bin_idx	ue(v)
lmcs_delta_cw_prec_minus1	ue(v)
for(i = lmcs_min_bin_idx; i <= LmcsMaxBinIdx; i++) {	
lmcs_delta_abs_cw[i]	u(v)
if(lmcs_delta_abs_cw[i]) > 0)	
lmcs_delta_sign_cw_flag[i]	u(1)

}	
lmcs_delta_abs_crs	u(3)
if(lmcs_delta_abs_crs) > 0)	
lmcs_delta_sign_crs_flag	u(1)
}	

Scaling list APS

The scaling list offers the possibility to update the quantization matrix used for quantification. In VVC this scaling matrix is signalled in the APS as described in Scaling list data syntax elements (

Table 7 Scaling list data syntax). The first syntax element specifies if the scaling matrix is used for the LFNST (Low Frequency Non-Separable Transform) tool based on the flag *scaling_matrix_for_lfnst_disabled_flag*. The second one is specified if the scaling list are used for Chroma components (*scaling_list_chroma_present_flag*). Then the syntax elements needed to build the scaling matrix are decoded (*scaling_list_copy_mode_flag, scaling_list_pred_mode_flag, scaling_list_pred_id_delta, scaling_list_dc_coef, scaling_list_delta_coef*).

Table 7 Scaling list data syntax

scaling_list_data( ) {	Descriptor
scaling_matrix_for_lfnst_disabled_flag	u(1)
scaling_list_chroma_present_flag	u(1)
for(id = 0; id < 28; id ++)	
matrixSize = (id < 2) ? 2 : ((id < 8) ? 4 : 8)	
if(scaling_list_chroma_present_flag || (id % 3 == 2) || (id == 27)) {	
scaling_list_copy_mode_flag[id]	u(1)
if(!scaling_list_copy_mode_flag[id])	
scaling_list_pred_mode_flag[id]	u(1)
if((scaling_list_copy_mode_flag[id] || scaling_list_pred_mode_flag[id]) && id != 0 && id != 2 && id != 8)	
scaling_list_pred_id_delta[id]	ue(v)
if(!scaling_list_copy_mode_flag[id]) {	
nextCoef = 0	
if(id > 13) {	
scaling_list_dc_coef[id − 14]	se(v)
nextCoef += scaling_list_dc_coef[id − 14]	
}	
for(i = 0; i < matrixSize * matrixSize; i++) {	
x = DiagScanOrder[3][3][i][0]	
y = DiagScanOrder[3][3][i][1]	
if(!(id > 25 && x >= 4 && y >= 4)) {	
scaling_list_delta_coef[id][i]	se(v)
nextCoef += scaling_list_delta_coef[id][i]	
}	
ScalingList[id][i] = nextCoef	
}	
}	
}	
}	
}	

Picture header

The picture header is transmitted at the beginning of each picture before the other Slice Data. This is very large compared to the previous headers in the previous drafts of the standard. A complete description of all these parameters can be found in JVET-Q2001-vD. Table 9 shows these parameters in the current picture header decoding syntax.

The related syntax elements which can be decoded are related to:

- the usage of this picture, reference frame or not
- The type of picture

- output frame
- The number of the Picture
- subpicture usage if needed
- reference picture lists if needed
- colour plane if needed
- partitioning update if overriding flag is enabled
- delta QP parameters if needed
- Motion information parameters if needed
- ALF parameters if needed
- SAO parameters if needed
- quantification parameters if needed
- LMCS parameters if needed
- Scaling list parameters if needed
- picture header extension if needed
- Etc…

Picture "type"

The first flag is the *gdr_or_irap_pic_flag* which indicates if the current picture is a resynchronisation picture (IRAP or GDR). If this flag is true, the *gdr_pic_flag* is decoded to know if the current picture is an IRAP or a GDR picture.

Then the *ph_inter_slice_allowed_flag* is decoded to identify that the Inter slice is allowed.

When they are allowed, the flag *ph_intra_slice_allowed_flag* is decoded to know if the Intra slice are allowed for the current picture.

Then the *non_reference_picture_flag*, the *ph_pic_parameter_set_id* indicating the PPS ID and the picture order count *ph_pic_order_cnt_lsb* are decoded. The picture order count gives the number of the current picture.

If the picture is a GDR or an IRAP picture, the flag *no_output_of_prior_pics_flag* is decoded.

And if the picture is a GDR the *recovery_poc_cnt* is decoded. Then *ph_poc_msb_present_flag* and *poc_msb_val* are decoded if needed.

ALF

After these parameters describing important information on the current picture, the set of ALF APS id syntax elements are decoded if ALF is enabled at SPS level and if ALF is

enabled at picture header level. ALF is enabled at SPS level thanks to the *sps_alf_enabled_flag* flag. And ALF signalling is enabled at picture header level thanks to the *alf_info_in_ph_flag* equal to 1 otherwise (alf_info_in_ph_flag equal to 0) ALF is signalled at slice level.

The alf_info_in_ph_flag is defined as the following:

"*alf_info_in_ph_flag equal to 1 specifies that ALF information is present in the PH syntax structure and not present in slice headers referring to the PPS that do not contain a PH syntax structure. alf_info_in_ph_flag equal to 0 specifies that ALF information is not present in the PH syntax structure and may be present in slice headers referring to the PPS that do not contain a PH syntax structure.*"

First the *ph_alf_enabled_present_flag* is decoded to determine whether or not if the *ph_alf_enabled_flag* should be decoded. If the *ph_alf_enabled_flag* is enabled, ALF is enabled for all slices of the current picture.

If ALF is enabled, the amount of ALF APS id for luma is decoded using the *pic_num_alf_aps_ids_luma* syntax element. For each APS id, the APS id value for luma is decoded "*ph_alf_aps_id_luma*".

For chroma the syntax element, *ph_alf_chroma_idc* is decoded to determine whether or not ALF is enabled for Chroma, for Cr only, or for Cb only. If it is enabled, the value of the APS ID for Chroma is decoded using the *ph_alf_aps_id_chroma* syntax element.

In the way the APS ID for CC-ALF method are decoded if needed for Cb and/or CR components

LMCS

The set of LMCS APS ID syntax elements is then decoded if LMCS was enabled at SPS level. First the *ph_lmcs_enabled_flag* is decoded to determine whether or not LMCS is enabled for the current picture. If LMCS is enabled, the ID value is decoded *ph_lmcs_aps_id*. For Chorma only the *ph_chroma_residual_scale_flag* is decoded to enable or disable the method for Chroma.

Scaling List

The set of scaling list APS ID is then decoded if the scaling list is enabled at SPS level. The *ph_scaling_list_present_flag* is decoded to determine whether or not the scaling matrix is enabled for the current picture. And the value of the APS ID, *ph_scaling_list_aps_id*, is then decoded.

Subpicture

The Subpicture parameters are enabled when they are enabled at SPS and if the subpicture id signalling is disabled. It also contains some information on virtual boundaries. For the sub picture parameters eight syntax elements are defined:

- *ph_virtual_boundaries_present_flag*
- *ph_num_ver_virtual_boundaries*
- *ph_virtual_boundaries_pos_x[i]*
- *ph_num_hor_virtual_boundaries*
- *ph_virtual_boundaries_pos_y[i]*

Output flag

These subpicture parameters are followed by the *pic_output_flag* if present.

Reference picture lists

If the reference picture lists are signalled in the picture header (thanks to rpl_info_in_ph_flag equal to 1), then the parameters for the reference picture lists are decoded *ref_pic_lists()* it contains the following syntax elements:

- *rpl_sps_flag[]*
- *rpl_idx[]*
- *poc_lsb_lt[][]*
- *delta_poc_msb_present_flag[ ][ ]*
- *delta_poc_msb_cycle_lt[ ][ ]*

Partitioning

The set of partitioning parameters is decoded if needed and contains the following syntax elements:

- *partition_constraints_override_flag*
- *ph_log2_diff_min_qt_min_cb_intra_slice_luma*
- *ph_max_mtt_hierarchy_depth_intra_slice_luma*
- *ph_log2_diff_max_bt_min_qt_intra_slice_luma*
- *ph_log2_diff_max_tt_min_qt_intra_slice_luma*
- *ph_log2_diff_min_qt_min_cb_intra_slice_chroma*
- *ph_max_mtt_hierarchy_depth_intra_slice_chroma*
- *ph_log2_diff_max_bt_min_qt_intra_slice_chroma*
- *ph_log2_diff_max_tt_min_qt_intra_slice_chroma*
- *ph_log2_diff_min_qt_min_cb_inter_slice*

- *ph_max_mtt_hierarchy_depth_inter_slice*
- *ph_log2_diff_max_bt_min_qt_inter_slice*
- *ph_log2_diff_max_tt_min_qt_inter_slice*

Weighted prediction

The weighted prediction parameters *pred_weight_table()* are decoded if the weighted prediction method is enabled at PPS level and if the weighted prediction parameters are signalled in the picture header (*wp_info_in_ph_flag* equal to 1*)*.

The *pred_weight_table()* contains the weighted prediction parameters for List L0 and for list L1 when bi-prediction weighted prediction is enabled. When the weighted prediction parameters are transmitted in the picture header the number of weights for each list are explicitly transmitted as depicted in the *pred_weight_table()* syntax table **Table 8**.

Table 8 Weighted prediction parameters syntax

pred_weight_table( ) {	**Descriptor**
luma_log2_weight_denom	ue(v)
if(ChromaArrayType != 0)	
delta_chroma_log2_weight_denom	se(v)
if(wp_info_in_ph_flag)	
num_l0_weights	ue(v)
for(i = 0; i < NumWeightsL0; i++)	
luma_weight_l0_flag[i]	u(1)
if(ChromaArrayType != 0)	
for(i = 0; i < NumWeightsL0; i++)	
chroma_weight_l0_flag[i]	u(1)
for(i = 0; i < NumWeightsL0; i++) {	
if(luma_weight_l0_flag[i]) {	
delta_luma_weight_l0[i]	se(v)
luma_offset_l0[i]	se(v)
}	
if(chroma_weight_l0_flag[i])	
for(j = 0; j < 2; j++) {	
delta_chroma_weight_l0[i][j]	se(v)
delta_chroma_offset_l0[i][j]	se(v)
}	
}	
if(pps_weighted_bipred_flag && wp_info_in_ph_flag)	
num_l1_weights	ue(v)
for(i = 0; i < NumWeightsL1; i++)	
luma_weight_l1_flag[i]	u(1)
if(ChromaArrayType != 0)	
for(i = 0; i < NumWeightsL1; i++)	
chroma_weight_l1_flag[i]	u(1)
for(i = 0; i < NumWeightsL1; i++) {	
if(luma_weight_l1_flag[i]) {	
delta_luma_weight_l1[i]	se(v)
luma_offset_l1[i]	se(v)
}	
if(chroma_weight_l1_flag[i])	
for(j = 0; j < 2; j++) {	
delta_chroma_weight_l1[i][j]	se(v)
delta_chroma_offset_l1[i][j]	se(v)
}	
}	
}	

Delta QP

When the picture is Intra the *ph_cu_qp_delta_subdiv_intra_slice* and the *ph_cu_chroma_qp_offset_subdiv_intra_slice* are decoded if needed. And if Inter slice is allowed the *ph_cu_qp_delta_subdiv_inter_slice* and the *ph_cu_chroma_qp_offset_subdiv_inter_slice* are decoded if needed. Finally, the picture header extension syntax elements are decoded if needed.

All parameters *alf_info_in_ph_flag*, *rpl_info_in_ph_flag*, *qp_delta_info_in_ph_flag* *sao_info_in_ph_flag*, *dbf_info_in_ph_flag*, *wp_info_in_ph_flag* are signalleed in the PPS.

Table 9 Picture header structure

picture_header_structure( ) {	**Descriptor**
gdr_or_irap_pic_flag	u(1)
if(gdr_or_irap_pic_flag)	
gdr_pic_flag	u(1)
ph_inter_slice_allowed_flag	u(1)
if(ph_inter_slice_allowed_flag)	
ph_intra_slice_allowed_flag	u(1)
non_reference_picture_flag	u(1)
ph_pic_parameter_set_id	ue(v)
ph_pic_order_cnt_lsb	u(v)
if(gdr_or_irap_pic_flag)	
no_output_of_prior_pics_flag	u(1)
if(gdr_pic_flag)	
recovery_poc_cnt	ue(v)
for(i = 0; i < NumExtraPhBits; i++)	
ph_extra_bit[i]	u(1)
if(sps_poc_msb_flag) {	
ph_poc_msb_present_flag	u(1)
if(ph_poc_msb_present_flag)	
poc_msb_val	u(v)
}	
if(sps_alf_enabled_flag && alf_info_in_ph_flag) {	
ph_alf_enabled_flag	u(1)
if(ph_alf_enabled_flag) {	
ph_num_alf_aps_ids_luma	u(3)
for(i = 0; i < ph_num_alf_aps_ids_luma; i++)	
ph_alf_aps_id_luma[i]	u(3)
if(ChromaArrayType != 0)	
ph_alf_chroma_idc	u(2)
if(ph_alf_chroma_idc > 0)	
ph_alf_aps_id_chroma	u(3)
if(sps_ccalf_enabled_flag) {	

ph_cc_alf_cb_enabled_flag	u(1)
if(ph_cc_alf_cb_enabled_flag)	
ph_cc_alf_cb_aps_id	u(3)
ph_cc_alf_cr_enabled_flag	u(1)
if(ph_cc_alf_cr_enabled_flag)	
ph_cc_alf_cr_aps_id	u(3)
}	
}	
}	
if(sps_lmcs_enabled_flag) {	
ph_lmcs_enabled_flag	u(1)
if(ph_lmcs_enabled_flag) {	
ph_lmcs_aps_id	u(2)
if(ChromaArrayType != 0)	
ph_chroma_residual_scale_flag	u(1)
}	
}	
if(sps_scaling_list_enabled_flag) {	
ph_scaling_list_present_flag	u(1)
if(ph_scaling_list_present_flag)	
ph_scaling_list_aps_id	u(3)
}	
if(sps_virtual_boundaries_enabled_flag && !sps_virtual_boundaries_present_flag) {	
ph_virtual_boundaries_present_flag	u(1)
if(ph_virtual_boundaries_present_flag) {	
ph_num_ver_virtual_boundaries	u(2)
for(i = 0; i < ph_num_ver_virtual_boundaries; i++)	
ph_virtual_boundaries_pos_x[i]	u(13)
ph_num_hor_virtual_boundaries	u(2)
for(i = 0; i < ph_num_hor_virtual_boundaries; i++)	
ph_virtual_boundaries_pos_y[i]	u(13)
}	
}	
if(output_flag_present_flag)	
pic_output_flag	u(1)
if(rpl_info_in_ph_flag)	
ref_pic_lists( )	
if(partition_constraints_override_enabled_flag)	
partition_constraints_override_flag	u(1)
if(ph_intra_slice_allowed_flag) {	
if(partition_constraints_override_flag) {	
ph_log2_diff_min_qt_min_cb_intra_slice_luma	ue(v)
ph_max_mtt_hierarchy_depth_intra_slice_luma	ue(v)
if(ph_max_mtt_hierarchy_depth_intra_slice_luma != 0) {	
ph_log2_diff_max_bt_min_qt_intra_slice_luma	ue(v)
ph_log2_diff_max_tt_min_qt_intra_slice_luma	ue(v)

}	
if(qtbtt_dual_tree_intra_flag) {	
ph_log2_diff_min_qt_min_cb_intra_slice_chroma	ue(v)
ph_max_mtt_hierarchy_depth_intra_slice_chroma	ue(v)
if(ph_max_mtt_hierarchy_depth_intra_slice_chroma != 0) {	
ph_log2_diff_max_bt_min_qt_intra_slice_chroma	ue(v)
ph_log2_diff_max_tt_min_qt_intra_slice_chroma	ue(v)
}	
}	
}	
if(cu_qp_delta_enabled_flag)	
ph_cu_qp_delta_subdiv_intra_slice	ue(v)
if(pps_cu_chroma_qp_offset_list_enabled_flag)	
ph_cu_chroma_qp_offset_subdiv_intra_slice	ue(v)
}	
if(ph_inter_slice_allowed_flag) {	
if(partition_constraints_override_flag) {	
ph_log2_diff_min_qt_min_cb_inter_slice	ue(v)
ph_max_mtt_hierarchy_depth_inter_slice	ue(v)
if(ph_max_mtt_hierarchy_depth_inter_slice != 0) {	
ph_log2_diff_max_bt_min_qt_inter_slice	ue(v)
ph_log2_diff_max_tt_min_qt_inter_slice	ue(v)
}	
}	
if(cu_qp_delta_enabled_flag)	
ph_cu_qp_delta_subdiv_inter_slice	ue(v)
if(pps_cu_chroma_qp_offset_list_enabled_flag)	
ph_cu_chroma_qp_offset_subdiv_inter_slice	ue(v)
if(sps_temporal_mvp_enabled_flag) {	
ph_temporal_mvp_enabled_flag	u(1)
if(ph_temporal_mvp_enabled_flag && rpl_info_in_ph_flag) {	
ph_collocated_from_l0_flag	u(1)
if((ph_collocated_from_l0_flag && num_ref_entries[0][RplsIdx[0]] > 1) || (!ph_collocated_from_l0_flag && num_ref_entries[1][RplsIdx[1]] > 1))	
ph_collocated_ref_idx	ue(v)
}	
}	
mvd_l1_zero_flag	u(1)
if(sps_fpel_mmvd_enabled_flag)	
ph_fpel_mmvd_enabled_flag	u(1)
if(sps_bdof_pic_present_flag)	
ph_disable_bdof_flag	u(1)
if(sps_dmvr_pic_present_flag)	
ph_disable_dmvr_flag	u(1)
if(sps_prof_pic_present_flag)	

ph_disable_prof_flag	u(1)
if((pps_weighted_pred_flag || pps_weighted_bipred_flag) && wp_info_in_ph_flag)	
pred_weight_table( )	
}	
if(qp_delta_info_in_ph_flag)	
ph_qp_delta	se(v)
if(sps_joint_cbcr_enabled_flag)	
ph_joint_cbcr_sign_flag	u(1)
if(sps_sao_enabled_flag && sao_info_in_ph_flag) {	
ph_sao_luma_enabled_flag	u(1)
if(ChromaArrayType != 0)	
ph_sao_chroma_enabled_flag	u(1)
}	
if(sps_dep_quant_enabled_flag)	
ph_dep_quant_enabled_flag	u(1)
if(sps_sign_data_hiding_enabled_flag && !ph_dep_quant_enabled_flag)	
pic_sign_data_hiding_enabled_flag	u(1)
if(deblocking_filter_override_enabled_flag && dbf_info_in_ph_flag) {	
ph_deblocking_filter_override_flag	u(1)
if(ph_deblocking_filter_override_flag) {	
ph_deblocking_filter_disabled_flag	u(1)
if(!ph_deblocking_filter_disabled_flag) {	
ph_beta_offset_div2	se(v)
ph_tc_offset_div2	se(v)
ph_cb_beta_offset_div2	se(v)
ph_cb_tc_offset_div2	se(v)
ph_cr_beta_offset_div2	se(v)
ph_cr_tc_offset_div2	se(v)
}	
}	
}	
if(picture_header_extension_present_flag) {	
ph_extension_length	ue(v)
for(i = 0; i < ph_extension_length; i++)	
ph_extension_data_byte[i]	u(8)
}	
}	

Slice header

The Slice header is transmitted at the beginning of each slice. The slice header contains about 65 syntax elements. This is very large compared to the previous slice header in earlier video coding standards. A complete description of all the slice header parameters can be found in JVET-Q2001-vD. Table 10 shows these parameters in a current slice header decoding syntax.

Table 10 Partial Slice header

slice_header( ) {	**Descriptor**
picture_header_in_slice_header_flag	u(1)
if(picture_header_in_slice_header_flag)	
picture_header_structure( )	
if(subpic_info_present_flag)	
slice_subpic_id	u(v)
if((rect_slice_flag && NumSlicesInSubpic[CurrSubpicIdx] > 1) || (!rect_slice_flag && NumTilesInPic > 1))	
slice_address	u(v)
for(i = 0; i < NumExtraShBits; i++)	
sh_extra_bit[i]	u(1)
if(!rect_slice_flag && NumTilesInPic > 1)	
num_tiles_in_slice_minus1	ue(v)
if(ph_inter_slice_allowed_flag)	
slice_type	ue(v)
if(sps_alf_enabled_flag && !alf_info_in_ph_flag) {	
slice_alf_enabled_flag	u(1)
if(slice_alf_enabled_flag) {	
slice_num_alf_aps_ids_luma	u(3)
for(i = 0; i < slice_num_alf_aps_ids_luma; i++)	
slice_alf_aps_id_luma[i]	u(3)
if(ChromaArrayType != 0)	
slice_alf_chroma_idc	u(2)
if(slice_alf_chroma_idc)	
slice_alf_aps_id_chroma	u(3)
if(sps_ccalf_enabled_flag) {	
slice_cc_alf_cb_enabled_flag	u(1)
if(slice_cc_alf_cb_enabled_flag)	
slice_cc_alf_cb_aps_id	u(3)
slice_cc_alf_cr_enabled_flag	u(1)
if(slice_cc_alf_cr_enabled_flag)	
slice_cc_alf_cr_aps_id	u(3)
}	
}	
}	
if(separate_colour_plane_flag == 1)	
colour_plane_id	u(2)
if(!rpl_info_in_ph_flag && ((nal_unit_type != IDR_W_RADL && nal_unit_type != IDR_N_LP) || sps_idr_rpl_present_flag))	
ref_pic_lists( )	
if((rpl_info_in_ph_flag || ((nal_unit_type != IDR_W_RADL && nal_unit_type != IDR_N_LP) || sps_idr_rpl_present_flag)) && ((slice_type != I && num_ref_entries[0][RplsIdx[0]] > 1) || (slice_type == B && num_ref_entries[1][RplsIdx[1]] > 1)) {	
num_ref_idx_active_override_flag	u(1)
if(num_ref_idx_active_override_flag)	
for(i = 0; i < (slice_type == B ? 2: 1); i++)	

if(num_ref_entries[i][RplsIdx[i]] > 1)	
num_ref_idx_active_minus1[i]	ue(v)
}	
if(slice_type != I) {	
if(cabac_init_present_flag)	
cabac_init_flag	u(1)
if(ph_temporal_mvp_enabled_flag && !rpl_info_in_ph_flag) {	
if(slice_type == B)	
slice_collocated_from_l0_flag	u(1)
if((slice_collocated_from_l0_flag && NumRefIdxActive[0] > 1) || (! slice_collocated_from_l0_flag && NumRefIdxActive[1] > 1))	
slice_collocated_ref_idx	ue(v)
}	
if(!wp_info_in_ph_flag && ((pps_weighted_pred_flag && slice_type == P) || (pps_weighted_bipred_flag && slice_type == B)))	
pred_weight_table( )	
}	
if(!qp_delta_info_in_ph_flag)	
slice_qp_delta	se(v)
if(pps_slice_chroma_qp_offsets_present_flag) {	
slice_cb_qp_offset	se(v)
slice_cr_qp_offset	se(v)
if(sps_joint_cbcr_enabled_flag)	
slice_joint_cbcr_qp_offset	se(v)
}	
if(pps_cu_chroma_qp_offset_list_enabled_flag)	
cu_chroma_qp_offset_enabled_flag	u(1)
if(sps_sao_enabled_flag && !sao_info_in_ph_flag) {	
slice_sao_luma_flag	u(1)
if(ChromaArrayType != 0)	
slice_sao_chroma_flag	u(1)
}	
if(deblocking_filter_override_enabled_flag && !dbf_info_in_ph_flag)	
slice_deblocking_filter_override_flag	u(1)
if(slice_deblocking_filter_override_flag) {	
slice_deblocking_filter_disabled_flag	u(1)
if(!slice_deblocking_filter_disabled_flag) {	
slice_beta_offset_div2	se(v)
slice_tc_offset_div2	se(v)
slice_cb_beta_offset_div2	se(v)
slice_cb_tc_offset_div2	se(v)
slice_cr_beta_offset_div2	se(v)
slice_cr_tc_offset_div2	se(v)
}	
}	
slice_ts_residual_coding_disabled_flag	u(1)

if(ph_lmcs_enabled_flag)	
slice_lmcs_enabled_flag	u(1)
if(ph_scaling_list_present_flag)	
slice_scaling_list_present_flag	u(1)
if(NumEntryPoints > 0) {	
offset_len_minus1	ue(v)
for(i = 0; i < NumEntryPoints; i++)	
entry_point_offset_minus1[i]	u(v)
}	
if(slice_header_extension_present_flag) {	
slice_header_extension_length	ue(v)
for(i = 0; i < slice_header_extension_length; i++)	
slice_header_extension_data_byte[i]	u(8)
}	
byte_alignment( )	
}	

First the *picture_header_in_slice_header_flag* is decoded to know if the picture_header_structure( ) is present in the slice header.

The *slice_subpic_id* if needed, is then decoded to determine the sub picture id of the current slice. Then the *slice_address* is decoded to determine the address of the current slice. The slice address is decoded if the current slice mode is the rectangular slice mode (*rect_slice_flag* equal to 1) and if the number of slices in the current subpicture is superior to 1. The slice address can be also decoded if the current slice mode is the raster scan mode (*rect_slice_flag* equal to 0) and if the number of tiles in the current picture is superior to 1 computed based on variables defined in the PPS.

The *num_tiles_in_slice_minus1* is then decoded if the number of tiles in the current picture is greater than one and if the current slice mode is not the rectangular slice mode. In the current VVC draft specifications, *num_tiles_in_slice_minus1* is defined as follow:

> "*num_tiles_in_slice_minus1* plus 1, when present, specifies the number of tiles in the slice. The value of num_tiles_in_slice_minus1 shall be in the range of 0 to NumTilesInPic − 1, inclusive."

Then the *slice_type* is decoded.

If ALF is enabled at SPS level (*sps_alf_enabled_flag*) and if ALF is signalled in the slice header (*alf_info_in_ph_flag* equal to 0), then ALF information is decoded. This includes a flag indicating that ALF is enabled for the current slice (*slice_alf_enabled_flag*). If it is enabled, the number of APS ALF ID for luma (*slice_num_alf_aps_ids_luma*) is decoded, then

the APS ID are decoded (*slice_alf_aps_id_luma[i]*). Then the *slice_alf_chroma_idc* is decoded to know if ALF is enabled for the Chroma components and which chroma component it is enabled. Then the APS ID for Chroma is decoded *slice_alf_aps_id_chroma* if needed. In the same way, the *slice_cc_alf_cb_enabled_flag* is decoded, if needed, to know if the CC ALF method is enabled. IF CC ALF is enabled, the related APS ID for CR and/or CB are decoded if CC ALF is enabled for CR and/or CB.

If the colour planes are transmitted independently (*separate_colour_plane_flag* equals to 1) the *colour_plane_id* is decoded.

When the reference picture lists are not transmitted in the picture header (*rpl_info_in_ph_flag* equal to 0) and when the Nal unit is not an IDR or if the reference pictures lists are transmitted for IDR pictures (*sps_idr_rpl_present_flag* equals to 1) then the Reference picture lists parameters are decoded; these are similar to those in the picture header.

If the reference picture lists are transmitted in the picture header (*rpl_info_in_ph_flag* equal to 1) or the Nal unit is not an IDR or if the reference picture lists are transmitted for IDR pictures (*sps_idr_rpl_present_flag* equals to 1) and if the number of reference for at least one list is superior to 1, the override flag *num_ref_idx_active_override_flag* is decoded.
If this flag is enabled the reference index for each list are decoded.

When the slice type is not intra and if needed the *cabac_init_flag* is decoded.If the reference picture lists are transmitted in the slice header and come other conditions, the *slice_collocated_from_l0_flag* and the *slice_collocated_ref_idx* are decoded. These data are related to the CABAC coding and the motion vector collocated.
In the same way, when the slice type is not Intra, the parameters of the weighted prediction *pred_weight_table( )* are decoded.

The *slice_qp_delta* is decoded bif the delta QP information is transmitted in the slice header (*qp_delta_info_in_ph_flag* equal to 0). If needed the syntax elements,
slice_cb_qp_offset, slice_cr_qp_offset, slice_joint_cbcr_qp_offset,
cu_chroma_qp_offset_enabled_flag are decoded.

If the SAO information are transmitted in the slice header (*sao_info_in_ph_flag* equal to 0) and if it is enabled at SPS level (*sps_sao_enabled_flag*), the enabled flags for SAO are decoded for both luma and chroma: *slice_sao_luma_flag, slice_sao_chroma_flag*.
Then the deblocking filter parameters are decoded if they are signalled in the slice header (*dbf_info_in_ph_flag* equal to 0).

The flag *slice_ts_residual_coding_disabled_flag* is systematically decoded to know if the Transform Skip residual coding method is enabled for the current slice.

If LMCS was enabled in the picture header (*ph_lmcs_enabled_flag* equal 1), the flag *slice_lmcs_enabled_flag* is decoded.

In the same way, if the scaling list was enabled in the picture header (*phpic_scaling_list_presentenabled_flag* equal 1), the flag *slice_scaling_list_present_flag* is decoded.

Then other parameters are decoded if needed.

Picture header in the slice header

In a particular signalling way, the picture header (708) can be signalled inside the slice header (710) as depicted in the **Figure** 7. In that case there is no NAL unit containing only the picture header (608). The NAL units 701-707 correspond to the respective NAL units 601-607 in **Figure 6**. Similarly, coding tiles 720 and coding blocks 740 correspond to the blocks 620 and 640 of **Figure 6**. Accordingly, explanation of these units and blocks will not be repeated here. This can be enabled in the slice header thanks to the flag picture_header_in_slice_header_flag. Moreover, when the picture header is signalled inside the slice header, the picture shall contain only one slice. So, there is always only one picture header per picture. Moreover, the flag picture_header_in_slice_header_flag shall have the same value for all pictures of a CLVS (Coded Layer Video Sequence). It means that all pictures between two IRAP including the first IRAP has only one slice per picture.

The flag picture_header_in_slice_header_flag is defined as the following:

"picture_header_in_slice_header_flag equal to 1 specifies that the PH syntax structure is present in the slice header. picture_header_in_slice_header_flag equal to 0 specifies that the PH syntax structure is not present in the slice header.

It is a requirement of bitstream conformance that the value of picture_header_in_slice_header_flag shall be the same in all coded slices in a CLVS.

When picture_header_in_slice_header_flag is equal to 1 for a coded slice, it is a requirement of bitstream conformance that no VCL NAL unit with nal_unit_type equal to PH_NUT shall be present in the CLVS.

When picture_header_in_slice_header_flag is equal to 0, all coded slices in the current picture shall have picture_header_in_slice_header_flag is equal to 0, and the current PU shall have a PH NAL unit.

The picture_header_structure( ) contains syntax elements of the picture_rbsp() except the stuffing bits rbsp_trailing_bits( )."

Streaming applications

Some streaming applications only extract certain parts of the bitstream. These extractions can be spatial (as the sub-picture) or temporal (a subpart of the video sequence). Then these extracted parts can be merged with other bitstreams. Some other reduce the frame rate by extracting only some frames. Generally, the main aim of these streaming applications is to use the maximum of the allowed bandwidth to produce the maximum quality to the end user.

In VVC, the APS ID numbering has been limited for frame rate reduction, in order that a new APS id number for a frame can't be used for a frame at an upper level in the temporal hierarchy. However, for streaming applications which extract parts of the bitstream the APS ID needs to be tracked to determine which APS should be keep for a sub part of the bitstream as the frame (as IRAP) don't reset the numbering of the APS ID.

LMCS (Luma mapping with chroma scaling)

The Luma Mapping with Chroma scaling (LMCS) technique is a sample value conversion method applied on a block before applying the loop filters in a video decoder like VVC.

The LMCS can be divided into two sub-tools. The first one is applied on Luma block while the second sub-tool is applied on Chroma blocks as described below:

1) The first sub-tool is an in-loop mapping of the Luma component based on adaptive piecewise linear models. The in-loop mapping of the Luma component adjusts the dynamic range of the input signal by redistributing the codewords across the dynamic range to improve compression efficiency. Luma mapping makes use of a forward mapping function into the “mapped domain” and a corresponding inverse mapping function to come back in the “input domain”.

2) The second sub-tool is related to the chroma components where a luma-dependent chroma residual scaling is applied. Chroma residual scaling is designed to compensate for the interaction between the luma signal and its corresponding chroma signals. Chroma residual scaling depends on the average value of top and/or left reconstructed neighbouring luma samples of the current block.

Like most other tools in video coder like VVC, LMCS can be enabled/disabled at the sequence level using an SPS flag. Whether chroma residual scaling is enabled or not is also signalled at the slice level. If luma mapping is enabled, an additional flag is signalled to indicate if luma-dependent chroma residual scaling is enabled or not. When luma mapping is not used, luma-dependent chroma residual scaling is fully disabled. In addition, luma-dependent chroma residual scaling is always disabled for the chroma blocks whose size is less than or equal to 4.

Figure 8 shows the principle of the LMCS as explained above for the Luma mapping sub-tool. The hatched blocks in **Figure 8** are the new LMCS functional blocks, including forward and inverse mapping of the luma signal. It is important to note that, when using LMCS, some decoding operations are applied in the "mapped domain". These operations are represented by blocks in dashed lines in this **Figure 8**. They typically correspond to the inverse quantization, the inverse transform, the luma intra prediction and the reconstruction step which consists in adding the luma prediction with the luma residual. Conversely, the solid line blocks in **Figure 8** indicate where the decoding process is applied in the original (i.e., non-mapped) domain and this includes the loop filtering such as deblocking, ALF, and SAO, the motion compensated prediction, and the storage of decoded pictures as reference pictures (DPB).

Figure 9 shows a similar diagram as **Figure 8** but this time this is for the Chroma scaling sub-tool of the LMCS tool. The hatched block in **Figure 9** is the new LMCS functional block which includes the luma-dependent chroma scaling process. However, in Chroma, there are some important differences compared to the Luma case. Here only the inverse quantization and the inverse transform represented by block in dash lines are performed in the "mapped domain" for the Chroma samples. All the other steps of Intra Chroma prediction, motion compensation, loop filtering are performed in the original domain. As depicted in **Figure** 9, there is only a scaling process and there is no forward and inverse processing as for the Luma mapping.

Luma mapping by using piece wise linear model.

The luma mapping sub-tool is using a piecewise linear model. It means that the piecewise linear model separates the input signal dynamic range into 16 equal sub-ranges, and for each sub-range, its linear mapping parameters are expressed using the number of codewords assigned to that range.

Semantics for Luma mapping

The syntax element *lmcs_min_bin_idx* specifies the minimum bin index used in the luma mapping with chroma scaling (LMCS) construction process. The value of *lmcs_min_bin_idx* shall be in the range of 0 to 15, inclusive.

The syntax element *lmcs_delta_max_bin_idx* specifies the delta value between 15 and the maximum bin index *LmcsMaxBinIdx* used in the luma mapping with chroma scaling construction process. The value of *lmcs_delta_max_bin_idx* shall be in the range of 0 to 15, inclusive. The value of *LmcsMaxBinIdx* is set equal to 15 − *lmcs_delta_max_bin_idx*. The value of *LmcsMaxBinIdx* shall be greater than or equal to *lmcs_min_bin_idx*.

The syntax element *lmcs_delta_cw_prec_minus1* plus 1 specifies the number of bits used for the representation of the syntax *lmcs_delta_abs_cw[i]*.

The syntax element *lmcs_delta_abs_cw[i]* specifies the absolute delta codeword value for the i_{th} bin.

The syntax element *lmcs_delta_sign_cw_flag[i]* specifies the sign of the variable *lmcsDeltaCW[i]*.When *lmcs_delta_sign_cw_flag[i]* is not present, it is inferred to be equal to 0.

LMCS intermediate variables computation for Luma mapping

In order to apply the forward and inverse Luma mapping processes, some intermediate variables and data arrays are needed.

First of all, the variable OrgCW is derived as follows:

OrgCW = (1 << BitDepth) / 16

Then, the variable lmcsDeltaCW[i], with i = lmcs_min_bin_idx .. LmcsMaxBinIdx, is computed as follows:

lmcsDeltaCW[i] = (1 − 2 * lmcs_delta_sign_cw_flag[i]) * lmcs_delta_abs_cw[i]

The new variable lmcsCW[i] is derived as follows:

- For i = 0.. lmcs_min_bin_idx − 1, lmcsCW[i] is set equal 0.
- For i = lmcs_min_bin_idx..LmcsMaxBinIdx, the following applies:

lmcsCW[i] = OrgCW + lmcsDeltaCW[i]

The value of lmcsCW[i] shall be in the range of (OrgCW>>3) to (OrgCW<<3 − 1), inclusive.

- For i = LmcsMaxBinIdx + 1..15, lmcsCW[i] is set equal 0.

The variable InputPivot[i], with i = 0..16, is derived as follows:

```
InputPivot[ i ] = i * OrgCW
```

The variable LmcsPivot[i] with i = 0..16, the variables ScaleCoeff[i] and InvScaleCoeff[i] with i = 0..15, are computed as follows:

```
LmcsPivot[ 0 ] = 0;
for( i = 0; i <= 15; i++ ) {
    LmcsPivot[ i + 1 ] = LmcsPivot[ i ] + lmcsCW[ i ]
    ScaleCoeff[ i ] = ( lmcsCW[ i ] * (1 << 11 ) + ( 1 <<
( Log2( OrgCW ) − 1 ) ) ) >> ( Log2( OrgCW ) )
    if( lmcsCW[ i ] == 0 )
        InvScaleCoeff[ i ] = 0
    else
        InvScaleCoeff[ i ] = OrgCW * ( 1 << 11 ) / lmcsCW[ i ]
```

Forward Luma mapping

As illustrated by **Figure 8** when the LMCS is applied for Luma, the Luma remapped sample called *predMapSamples[i][j]* is obtained from the prediction sample *predSamples[i][j].*

The *predMapSamples[i][j]* is computed as follows:

First of all, an index idxY is computed from the prediction sample *predSamples[i][j]*, at location (i, j)

```
idxY = predSamples[ i ][ j ] >> Log2( OrgCW )
```

Then predMapSamples[i][j] is derived as follows by using the intermediate variables idxY, LmcsPivot[idxY] and InputPivot[idxY] of section 0:

```
predMapSamples[ i ][ j ] = LmcsPivot[ idxY ]
 + ( ScaleCoeff[ idxY ] * ( predSamples[ i ][ j ] − InputPivot[ idxY ] ) + ( 1 <<
 10 ) ) >> 11
```

Luma reconstruction samples

The reconstruction process is obtained from the predicted luma sample *predMapSample[i][j]* and the residual luma samples *resiSamples[i][j].*

The reconstructed luma picture sample *recSamples [i][j]* is simply obtained by adding *predMapSample[i][j]* to *resiSamples[i][j]* as follows:

recSamples[i][j] = Clip1(predMapSamples[i][j]+ resiSamples[i][j]])

In this above relation, the Clip 1 function is a clipping function to make sure that the reconstructed sample is bewteen 0 and 1<< BitDepth -1.

Inverse Luma mapping

When applying the inverse luma mapping according to **Figure** 8, the following operations are applied on each sample *recSample[i][j]* of the current block being processed:

First, an index idxY is computed from the reconstruction sample *recSamples[i][j],* at location (i,j)

idxY = recSamples[i][j] >> Log2(OrgCW)

The inverse mapped luma sample invLumaSample[i][j] is derived as follows based on the:

invLumaSample[i][j] =

InputPivot[idxYInv] + (InvScaleCoeff[idxYInv] *

(recSample[i][j] − LmcsPivot[idxYInv]) + (1 << 10)) >> 11

A clipping operation is then done to get the final sample:

finalSample[i][j] = Clip1(invLumaSample[i][j])

Chroma scaling

LMCS semantics for Chroma scaling

The syntax element *lmcs_delta_abs_crs* in **Table 6** specifies the absolute codeword value of the variable *lmcsDeltaCrs*. The value of *lmcs_delta_abs_crs* shall be in the range of 0 and 7, inclusive. When not present, *lmcs_delta_abs_crs* is inferred to be equal to 0.

The syntax element *lmcs_delta_sign_crs_flag* specifies the sign of the variable *lmcsDeltaCrs*. When not present, *lmcs_delta_sign_crs_flag* is inferred to be equal to 0.

LMCS intermediate variable computation for Chroma scaling

To apply the Chroma scaling process, some intermediate variables are needed.

The variable *lmcsDeltaCrs* is derived as follows:

lmcsDeltaCrs = (1 − 2 * lmcs_delta_sign_crs_flag) * lmcs_delta_abs_crs

The variable *ChromaScaleCoeff[i]*, with i = 0...15, is derived as follows:

```
if( lmcsCW[ i ] == 0 )
  ChromaScaleCoeff[ i ] = ( 1 << 11 )
else
  ChromaScaleCoeff[ i ] = OrgCW * ( 1 << 11 ) / ( lmcsCW[ i ] + lmcsDeltaCrs )
```

Chroma scaling process

In a first step, the variable *invAvgLuma* is derived in order to compute the average luma value of reconstructed Luma samples around the current corresponding Chroma block. The average Luma is computed from left and top luma block surrounding the corresponding Chroma block

If no sample is available the variable *invAvgLuma* is set as follows:

```
invAvgLuma = 1 << ( BitDepth − 1 )
```

Based on the intermediate arrays *LmcsPivot[ ]* of section 0, the variable idxYInv is then derived as follows:

```
For ( idxYInv = lmcs_min_bin_idx; idxYInv <= LmcsMaxBinIdx; idxYInv++ ) {
        if(invAvgLuma < LmcsPivot [ idxYInv + 1 ] )        break
}
IdxYInv = Min( idxYInv, 15 )
```

The variable varScale is derived as follows:

```
varScale = ChromaScaleCoeff[ idxYInv ]
```

When a transform is applied on the current Chroma block, the reconstructed Chroma picture sample array *recSamples* is derived as follows

```
recSamples[i ][j ] = Clip1( predSamples[ i ][ j ] +
        Sign( resiSamples[ i ][ j ] ) * ( ( Abs( resiSamples[ i ][ j ] ) * varScale +
( 1 << 10 ) ) >> 11 ) )
```

If no transform has been applied for the current block, the following applies:

```
recSamples[ i ][ j ] = Clip1(predSamples[ i ][ j ] )
```

Encoder consideration

The basic principle of an LMCS encoder is to first assign more codewords to ranges where those dynamic range segments have lower codewords than the average variance. In an alternative formulation of this, the main target of LMCS is to assign fewer codewords to those dynamic range segments that have higher codewords than the average variance. In this way, smooth areas of the picture will be coded with more codewords than average, and vice versa.

All the parameters (see **Table 6**) of the LMCS tools which are stored in the APS are determined at the encoder side. The LMCS encoder algorithm is based on the evaluation of local luma variance and is optimizing the determination of the LMCS parameters according to the basic principle described above. The optimization is then conducted to get the best PSNR metrics for the final reconstructed samples of a given block.

Embodiments

Avoid Slice address syntax element when not needed

In one embodiment, when the picture header is signalled in the slice header, the slice address syntax element (*slice_address*), is inferred to be equal to the value 0 even if the number of tiles is greater than 1. **Table 11** illustrates this embodiment.

The advantage of this embodiment is that the slice address is not parsed when the picture header is in the slice header which reduces the bitrate, especially for low delay and low bitrate applications, and it reduces the parsing complexity for some implementations when the picture is signalled in the slice header.

In an embodiment this is applied only for raster-scan slice mode (*rect_slice_flag* equal to 0). This reduces the parsing complexity for some implementations.

Table 11 Partial Slice header showing modifications

slice_header( ) {	**Descriptor**
picture_header_in_slice_header_flag	u(1)
if(picture_header_in_slice_header_flag)	
picture_header_structure( )	
…	
if((rect_slice_flag && NumSlicesInSubpic[CurrSubpicIdx] > 1) || ((!rect_slice_flag && NumTilesInPic > 1) && !picture_header_in_slice_header_flag))	
slice_address	u(v)
…	

Avoid transmission of the number of tiles in the slice when not needed

In one embodiment the number of tiles in the slice is not transmitted when the picture header is transmitted in the slice header. **Table 12** illustrates this embodiment, where *num_tiles_in_slice_minus1* syntax element is not transmitted when the flag *picture_header_in_slice_header_flag* is set equal to 1. The advantage of this embodiment is a bitrate reduction, especially for low delay and low bitrate applications, as the number of tiles doesn't need to be transmitted.

In an embodiment this is applied only for raster-scan slice mode (*rect_slice_flag* equal to 0). This reduces the parsing complexity for some implementations.

Table 12 Partial Slice header showing modifications

slice_header( ) {	**Descriptor**
picture_header_in_slice_header_flag	u(1)
if(picture_header_in_slice_header_flag)	
picture_header_structure( )	
…	
if((!rect_slice_flag && NumTilesInPic > 1) && !picture_header_in_slice_header_flag)	
num_tiles_in_slice_minus1	ue(v)
…	

Predicted by PPS value NumTilesInPic (Semantics)

In one additional embodiment, the number of tiles in the current slice is inferred to be equal to the number of tiles in the picture when the picture header is transmitted in the slice header. This can be set by adding the following sentence in the semantics of the syntax element *num_tiles_in_slice_minus1*: "*When not present the variable num_tiles_in_slice_minus1 is set equal to NumTilesInPic-1*".

Where the variable *NumTilesInPic* gives the maximum number of tiles for the picture. This variable is computed based on syntax elements transmitted in the PPS.

Set the number of tiles before the slice address and avoid non needed transmission of slice_address

In one embodiment, the syntax element dedicated to the number of tiles in the slice is transmitted before the slice address and its value is used to know if it is needed to decode the slice address. More precisely, the number of tiles in the slice is compared to the number of tiles in the picture to know if it is needed to decode the slice address. Indeed, if the number of tiles in the slice is equal to the number of tiles in the picture it is sure that the current picture contains only one slice.

In an embodiment this is applied only for raster-scan slice mode (*rect_slice_flag* equal to 0). This reduces the parsing complexity for some implementations.

Table 13 illustrates this embodiment. Where the syntax element *slice_address* is not decoded if the value of the syntax element *num_tiles_in_slice_minus1* is equal to the variable *NumTilesInPic* minus 1. When *um_tiles_in_slice_minus1* is equal to the variable *NumTilesInPic* minus 1, the *slice_address* is inferred to be equal to 0.

Table 13 Partial Slice header showing modifications

slice_header( ) {	**Descriptor**
picture_header_in_slice_header_flag	u(1)
if(picture_header_in_slice_header_flag)	
picture_header_structure( )	
…	
if(!rect_slice_flag && NumTilesInPic > 1)	
num_tiles_in_slice_minus1	**ue(v)**
if((rect_slice_flag && NumSlicesInSubpic[CurrSubpicIdx] > 1) || ((!rect_slice_flag && NumTilesInPic > 1) && num_tiles_in_slice_minus1 != NumTilesInPic-1)	
slice_address	u(v)
…	

The advantage of this embodiment is a bitrate reduction and parsing complexity reduction when the condition is set equal to true as the slice address is not transmitted.

In one embodiment, the syntax element indicating the number of tiles in the current slice is not decoded and the number of tiles in the slice is inferred to be equal to 1 when the picture header is transmitted the slice header. And the slice address is inferred to be equal to 0, and the related syntax element is not decoded when the number of tiles in the slice is equal to the number of tiles in the picture. **Table 14** illustrates this embodiment.

This increases the bitrate reduction obtained by the combination of these 2 embodiments.

Table 14 Partial Slice header showing modifications

slice_header( ) {	**Descriptor**
picture_header_in_slice_header_flag	u(1)
if(picture_header_in_slice_header_flag)	
picture_header_structure( )	
…	
if((!rect_slice_flag && NumTilesInPic > 1) && !picture_header_in_slice_header_flag)	
num_tiles_in_slice_minus1	**ue(v)**
if((rect_slice_flag && NumSlicesInSubpic[CurrSubpicIdx] > 1) || ((!rect_slice_flag && NumTilesInPic > 1) && num_tiles_in_slice_minus1 != NumTilesInPic-1)	
slice_address	u(v)
…	

Remove un-needed conditions numTileInPic > 1

In one embodiment, a condition that the number of tiles in the current picture does need to be greater than 1 is not necessary to be tested when the raster-scan slice mode is enabled, in order for the syntax elements *slice_address* and/or the number of tiles in the current slice to be decoded. Specifically, when the number of tiles in the current picture is equal to 1 the *rect_slice_flag* value is inferred to be equal to 1. Consequently, the raster-scan slice mode can't be enabled in that case. **Table 15** Illustrates this embodiment.

This embodiment reduces the parsing complexity of the slice header.

Table 15 Partial Slice header showing modifications

slice_header( ) {	**Descriptor**
…	
if((rect_slice_flag && NumSlicesInSubpic[CurrSubpicIdx] > 1) || (!rect_slice_flag ~~&& NumTilesInPic > 1~~))	
slice_address	u(v)
for(i = 0; i < NumExtraShBits; i++)	
sh_extra_bit[i]	u(1)
if(!rect_slice_flag ~~&& NumTilesInPic > 1~~)	
num_tiles_in_slice_minus1	ue(v)
…	

In one embodiment, the syntax element indicating the number of tiles in the current slice is not decoded and the number of tiles in the slice is inferred to be equal to 1 when the picture header

is transmitted in the slice header and when the raster-scan slices mode is enabled. And the slice address is inferred to be equal to 0, and the related syntax element *slice_address* is not decoded when the number of tiles in the slice is equal to the number of tiles in the picture and when the raster-scan slices mode is enabled. **Table 16** illustrates this embodiment.

The advantages are a bitrate reduction and a parsing complexity reduction.

Table 16 Partial Slice header showing modifications

slice_header( ) {	**Descriptor**
picture_header_in_slice_header_flag	u(1)
if(picture_header_in_slice_header_flag)	
picture_header_structure( )	
…	
if(!rect_slice_flag && !picture_header_in_slice_header_flag)	
num_tiles_in_slice_minus1	**ue(v)**
if((rect_slice_flag && NumSlicesInSubpic[CurrSubpicIdx] > 1) || (!rect_slice_flag && num_tiles_in_slice_minus1 != NumTilesInPic-1)	
slice_address	u(v)
…	

Implementations

Figure 11 shows a system **191** **195** comprising at least one of an encoder **150** or a decoder **100** and a communication network **199** according to embodiments of the present invention. According to an embodiment, the system **195** is for processing and providing a content (for example, a video and audio content for displaying/outputting or streaming video/audio content) to a user, who has access to the decoder **100**, for example through a user interface of a user terminal comprising the decoder **100** or a user terminal that is communicable with the decoder **100**. Such a user terminal may be a computer, a mobile phone, a tablet or any other type of a device capable of providing/displaying the (provided/streamed) content to the user. The system **195** obtains/receives a bitstream **101** (in the form of a continuous stream or a signal – e.g. while earlier video/audio are being displayed/output) via the communication network **199**. According to an embodiment, the system **191** is for processing a content and storing the processed content, for example a video and audio content processed for displaying/outputting/streaming at a later time. The system **191** obtains/receives a content comprising an original sequence of images **151**, which is received and processed (including filtering with a deblocking filter according to the present invention) by the encoder **150**, and the encoder **150** generates a bitstream **101** that is to be communicated to the decoder **100** via a

communication network **191**. The bitstream **101** is then communicated to the decoder **100** in a number of ways, for example it may be generated in advance by the encoder **150** and stored as data in a storage apparatus in the communication network **199** (e.g. on a server or a cloud storage) until a user requests the content (i.e. the bitstream data) from the storage apparatus, at which point the data is communicated/streamed to the decoder **100** from the storage apparatus. The system **191** may also comprise a content providing apparatus for providing/streaming, to the user (e.g. by communicating data for a user interface to be displayed on a user terminal), content information for the content stored in the storage apparatus (e.g. the title of the content and other meta/storage location data for identifying, selecting and requesting the content), and for receiving and processing a user request for a content so that the requested content can be delivered/streamed from the storage apparatus to the user terminal. Alternatively, the encoder **150** generates the bitstream **101** and communicates/streams it directly to the decoder **100** as and when the user requests the content. The decoder **100** then receives the bitstream **101** (or a signal) and performs filtering with a deblocking filter according to the invention to obtain/generate a video signal **109** and/or audio signal, which is then used by a user terminal to provide the requested content to the user.

Any step of the method/process according to the invention or functions described herein may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the steps/functions may be stored on or transmitted over, as one or more instructions or code or program, or a computer-readable medium, and executed by one or more hardware-based processing unit such as a programmable computing machine, which may be a PC ("Personal Computer"), a DSP ("Digital Signal Processor"), a circuit, a circuitry, a processor and a memory, a general purpose microprocessor or a central processing unit, a microcontroller, an ASIC ("Application-Specific Integrated Circuit"), a field programmable logic arrays (FPGAs), or other equivalent integrated or discrete logic circuitry. Accordingly, the term "processor" as used herein may refer to any of the foregoing structure or any other structure suitable for implementation of the techniques describe herein.

Embodiments of the present invention can also be realized by wide variety of devices or apparatuses, including a wireless handset, an integrated circuit (IC) or a set of JCs (e.g. a chip set). Various components, modules, or units are described herein to illustrate functional aspects of devices/apparatuses configured to perform those embodiments, but do not necessarily require realization by different hardware units. Rather, various modules/units may be combined in a codec hardware unit or provided by a collection of interoperative hardware units, including one or more processors in conjunction with suitable software/firmware.

Embodiments of the present invention can be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium to perform the modules/units/functions of one or more of the above-described embodiments and/or that includes one or more processing unit or circuits for performing the functions of one or more of the above-described embodiments, and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiments and/or controlling the one or more processing unit or circuits to perform the functions of one or more of the above-described embodiments. The computer may include a network of separate computers or separate processing units to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a computer-readable medium such as a communication medium via a network or a tangible storage medium. The communication medium may be a signal/bitstream/carrier wave. The tangible storage medium is a "non-transitory computer-readable storage medium" which may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like. At least some of the steps/functions may also be implemented in hardware by a machine or a dedicated component, such as an FPGA ("Field-Programmable Gate Array") or an ASIC ("Application-Specific Integrated Circuit").

Figure 12 is a schematic block diagram of a computing device **2000** for implementation of one or more embodiments of the invention. The computing device **2000** may be a device such as a micro-computer, a workstation or a light portable device. The computing device **2000** comprises a communication bus connected to: - a central processing unit (CPU) **2001**, such as a microprocessor; - a random access memory (RAM) **2002** for storing the executable code of the method of embodiments of the invention as well as the registers adapted to record variables and parameters necessary for implementing the method for encoding or decoding at least part of an image according to embodiments of the invention, the memory capacity thereof can be expanded by an optional RAM connected to an expansion port for example; - a read only memory (ROM) **2003** for storing computer programs for implementing embodiments of the invention; - a network interface (NET) **2004** is typically connected to a communication network over which digital data to be processed are transmitted or received. The network interface (NET) **2004** can be a single network interface, or composed of a set of different

network interfaces (for instance wired and wireless interfaces, or different kinds of wired or wireless interfaces). Data packets are written to the network interface for transmission or are read from the network interface for reception under the control of the software application running in the CPU **2001**; - a user interface (UI) **2005** may be used for receiving inputs from a user or to display information to a user; - a hard disk (HD) **2006** may be provided as a mass storage device; - an Input/Output module (IO) **2007** may be used for receiving/sending data from/to external devices such as a video source or display. The executable code may be stored either in the ROM **2003**, on the HD **2006** or on a removable digital medium such as, for example a disk. According to a variant, the executable code of the programs can be received by means of a communication network, via the NET **2004**, in order to be stored in one of the storage means of the communication device **2000**, such as the HD **2006**, before being executed. The CPU **2001** is adapted to control and direct the execution of the instructions or portions of software code of the program or programs according to embodiments of the invention, which instructions are stored in one of the aforementioned storage means. After powering on, the CPU **2001** is capable of executing instructions from main RAM memory **2002** relating to a software application after those instructions have been loaded from the program ROM **2003** or the HD **2006**, for example. Such a software application, when executed by the CPU **2001**, causes the steps of the method according to the invention to be performed.

It is also understood that according to another embodiment of the present invention, a decoder according to an aforementioned embodiment is provided in a user terminal such as a computer, a mobile phone (a cellular phone), a table or any other type of a device (e.g. a display apparatus) capable of providing/displaying a content to a user. According to yet another embodiment, an encoder according to an aforementioned embodiment is provided in an image capturing apparatus which also comprises a camera, a video camera or a network camera (e.g. a closed-circuit television or video surveillance camera) which captures and provides the content for the encoder to encode. Two such examples are provided below with reference to Figures 13 and 14.

NETWORK CAMERA

FIG. 13 is a diagram illustrating a network camera system 2100 including a network camera 2102 and a client apparatus 2104.

The network camera 2102 includes an imaging unit 2106, an encoding unit 2108, a communication unit 2110, and a control unit 2112.

The network camera 2102 and the client apparatus 2104 are mutually connected to be able to communicate with each other via the network 200.

The imaging unit 2106 includes a lens and an image sensor (e.g., a charge coupled device (CCD) or a complementary metal oxide semiconductor (CMOS)), and captures an image of an object and generates image data based on the image. This image can be a still image or a video image.

The encoding unit 2108 encodes the image data by using said encoding methods described above

The communication unit 2110 of the network camera 2102 transmits the encoded image data encoded by the encoding unit 2108 to the client apparatus 2104.

Further, the communication unit 2110 receives commands from client apparatus 2104. The commands include commands to set parameters for the encoding of the encoding unit 2108.

The control unit 2112 controls other units in the network camera 2102 in accordance with the commands received by the communication unit 2110..

The client apparatus 2104 includes a communication unit 2114, a decoding unit 2116, and a control unit 2118.

The communication unit 2114 of the client apparatus 2104 transmits the commands to the network camera 2102.

Further, the communication unit 2114 of the client apparatus 2104 receives the encoded image data from the network camera 2102.

The decoding unit 2116 decodes the encoded image data by using said decoding methods described above.

The control unit 2118 of the client apparatus 2104 controls other units in the client apparatus 2104 in accordance with the user operation or commands received by the communication unit 2114.

The control unit 2118 of the client apparatus 2104 controls a display apparatus 2120 so as to display an image decoded by the decoding unit 2116.

The control unit 2118 of the client apparatus 2104 also controls a display apparatus 2120 so as to display GUI (Graphical User Interface) to designate values of the parameters for the network camera 2102 includes the parameters for the encoding of the encoding unit 2108.

The control unit 2118 of the client apparatus 2104 also controls other units in the client apparatus 2104 in accordance with user operation input to the GUI displayed by the display apparatus 2120.

The control unit 2119 of the client apparatus 2104 controls the communication unit 2114 of the client apparatus 2104 so as to transmit the commands to the network camera 2102

which designate values of the parameters for the network camera 2102, in accordance with the user operation input to the GUI displayed by the display apparatus 2120.

SMART PHONE

FIG. 14 is a diagram illustrating a smart phone 2200.

The smart phone 2200 includes a communication unit 2202, a decoding unit 2204, a control unit 2206, display unit 2208, an image recording device 2210 and sensors 2212.

the communication unit 2202 receives the encoded image data via network 200.

The decoding unit 2204 decodes the encoded image data received by the communication unit 2202.

The decoding unit 2204 decodes the encoded image data by using said decoding methods described above.

The control unit 2206 controls other units in the smart phone 2200 in accordance with a user operation or commands received by the communication unit 2202.

For example, the control unit 2206 controls a display unit 2208 so as to display an image decoded by the decoding unit 2204.

While the present invention has been described with reference to embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. It will be appreciated by those skilled in the art that various changes and modification might be made without departing from the scope of the invention, as defined in the appended claims. All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

It is also understood that any result of comparison, determination, assessment, selection, execution, performing, or consideration described above, for example a selection made during an encoding or filtering process, may be indicated in or determinable/inferable from data in a bitstream, for example a flag or data indicative of the result, so that the indicated or determined/inferred result can be used in the processing instead of actually performing the

comparison, determination, assessment, selection, execution, performing, or consideration, for example during a decoding process.

In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that different features are recited in mutually different dependent claims does not indicate that a combination of these features cannot be advantageously used.

Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

CLAIMS

1. A method of decoding video data from a bitstream, the bitstream comprising video data corresponding to one or more slices, wherein each slice may include one or more tiles,

wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when decoding a slice, and wherein the method comprises:

parsing syntax elements;

decoding weighted prediction parameters from the picture header depending on a value of a flag in a picture parameter set, wherein the flag indicates, when the value is 1, that the weighted prediction parameters could be present in the picture header;

in a case where a slice includes multiple tiles,

omitting parsing of a first syntax element indicating an address of the slice if a second syntax element which is parsed indicates that a picture header is present in the slice header; and

decoding the video data from said bitstream, using the parsed syntax elements.

2. A method according to claim 1, wherein the omitting is to be performed when a raster-scan slice mode is to be used for decoding the slice.

3. A method according to claim 1 or claim 2, wherein the, omitting further comprises omitting the parsing of a syntax element indicating a number of tiles in the slice.

4. A method of encoding video data into a bitstream, the bitstream comprising the video data corresponding to one or more slices, wherein each slice may include one or more tiles,

wherein the bitstream comprises a picture header comprising syntax elements to be used when decoding one or more slices, and a slice header comprising syntax elements to be used when encoding a slice, and the method comprises:

determining one or more syntax elements for encoding the video data;

encoding weighted prediction parameters in the picture header depending on a value of a flag in a picture parameter set, wherein the flag indicates, when the value of

the flag is 1, that the weighted prediction parameters could be present in the picture header;

in a case where a slice includes multiple tiles,

omitting encoding of a first syntax element indicating an address of the slice if a second syntax element indicates that a picture header is present in the slice header; and

encoding said video data using one or more syntax elements.

5. A method according to claim 4, wherein the omitting is to be performed is when a raster-scan slice mode is used for encoding the slice.

6. A method according to claims 4 or 5, wherein the omitting further comprises omitting the encoding of a syntax element indicating a number of tiles in the slice

7. A decoder for decoding video data from a bitstream, the decoder being configured to perform the method of any of claims 1 to 3.

8. An encoder for encoding video data into a bitstream, the encoder being configured to perform the method of any of claims 4 to 6.

9. A computer program which upon execution causes the method of any of claims 1 to 6 to be performed.