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[Continued on next page]

(54) Title: APPARATUS AND METHOD FOR DYNAMICALLY CHANGING ENCODING SCHEME BASED ON RESOURCE UTILIZATION

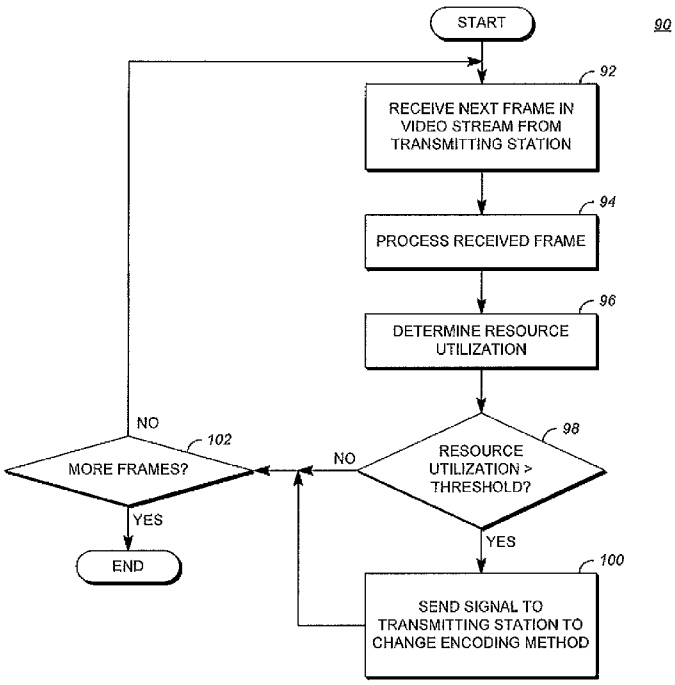

FIG. 4

(57) Abstract: A system, apparatus, and method for encoding and decoding a video stream having a plurality of frames is disclosed. The embodiments include receiving one or more initial encoded frames of the plurality of frames from a transmitting station, the one or more initial encoded frames encoded using a first encoding scheme, processing the one or more initial encoded frames using a computing device having a processor, determining the resource utilization of the computing device, and if the resource utilization exceeds a threshold, sending a request to the transmitting station to encode frames of the plurality of frames using a second encoding scheme that requires fewer resources to decode.

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APPARATUS AND METHOD FOR DYNAMICALLY CHANGING ENCODING SCHEME BASED ON RESOURCE UTILIZATION

TECHNICAL FIELD

[0001] The present invention relates in general to video encoding and decoding.

BACKGROUND

[0002] An increasing number of applications today make use of digital video for various purposes including, for example, remote business meetings via video conferencing, high definition video entertainment, video advertisements, and sharing of user-generated videos. As technology is evolving, users have higher expectations for video quality and expect high resolution video even when transmitted over communications channels having limited bandwidth. One type of video transmission includes real-time encoding and transmission, in which the receiver of a video stream decodes and renders frames as they are received.

[0003] To permit transmission of digital video streams while limiting bandwidth consumption, a number of video compression schemes have been devised, including formats such as VPx, promulgated by Google, Inc. of Mountain View, California, and H.264, a standard promulgated by ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG), including present and future versions thereof. H.264 is also known as MPEG-4 Part 10 or MPEG-4 AVC (formally, ISO/IEC 14496-10).

SUMMARY

[0004] Disclosed herein are embodiments of methods and apparatuses for encoding and decoding a video stream.

[0005] One aspect of the disclosed embodiments is a method for decoding a video stream having a plurality of frames. The method includes receiving one or more initial encoded frames of the plurality of frames from a transmitting station, the one or more initial encoded frames encoded using a first encoding scheme, processing the one or more initial encoded frames using a computing device having a processor, determining the resource utilization of the computing device, and if the resource utilization exceeds a threshold, sending a request to the transmitting

station to encode frames of the plurality of frames using a second encoding scheme that requires fewer resources to decode.

[0006] The method can include the resource utilization being at least one of processor utilization, memory utilization, or graphics card utilization.

[0007] The method can include attempting to reduce the computing device's resource utilization by using resource management techniques.

[0008] The method can include attempting to reduce the processor utilization by eliminating or throttling non-decoding-related processes.

[0009] The method can include rendering frames for display on a device configured to display the frames at a specified resolution, wherein the threshold is determined at least in part by the specified resolution.

[0010] The second encoding scheme can include encoding at the specified resolution.

[0011] The second encoding scheme can include encoding the video stream at a lower resolution or frame rate than the resolution or frame rate at which the video stream is encoded using the first encoding scheme.

[0012] The processing can include any of buffering, decoding, or rendering the initial encoded frames.

[0013] Another aspect of the disclosed embodiments is a method for decoding a video stream having a plurality of frames. The method includes receiving one or more initial frames of the plurality of frames, decoding the one or more initial frames using a processor, determining that the processor utilization exceeds a threshold, attempting to reduce the processor utilization, and requesting that subsequent frames of the plurality of frames be encoded at a lower resolution, a lower frame rate, or both.

[0014] The method can include steps where the receiving and the requesting are performed between at least one receiving station and at least one transmitting station.

[0015] Another aspect of the disclosed embodiments is an apparatus for rendering a current frame from a video stream's plurality of frames. The apparatus comprises a memory and at least one processor configured to execute instructions stored in the memory to receive one or more initial encoded frames of the plurality of frames from a transmitting station, the one or more initial encoded frames encoded using a first encoding scheme, decode the one or more initial encoded frames, determine the resource utilization of the computing device, and if the

resource utilization exceeds a threshold, send a request to the transmitting station to encode that subsequent encoded frames using a second encoding scheme that requires less computing device resources to decode.

[0016] The method can include sending a signal to the transmitting station requesting that subsequent encoded frames of the plurality of frames be encoded using a second encoding scheme that requires less computing device resources to decode.

[0017] The resource utilization can include at least one of processor utilization, memory utilization, or graphics card utilization.

[0018] The second encoding scheme can include instructions to encode the video stream at a lower resolution or frame rate than the resolution or frame rate at which the video stream is encoded using the first encoding scheme.

[0019] The computing device can include instructions to attempt to reduce the computing device's resource utilization by using resource management techniques.

[0020] Another aspect of the disclosed embodiments is a method for encoding a video stream having a plurality of frames. The method includes encoding one or more initial frames in the plurality of frames using a first encoding scheme, transmitting the initial encoded frames to a receiving station, receiving a signal from a receiving station requesting that future frames transmitted to the receiving station be encoded using a second encoding scheme that requires fewer resources for decoding, encoding one or more subsequent frames from the plurality of frames using the second encoding scheme, and transmitting the subsequent encoded frames to the receiving station.

[0021] The signal can include a request that subsequent frames be encoded at a lower resolution or a lower frame rate.

[0022] The subsequent encoded frames can be encoded at a lower resolution or a lower frame rate.

[0023] The second encoding scheme can be selected by the encoder.

[0024] The method can include transmitting the initial encoded frames to one or more additional receiving stations and transmitting the subsequent encoded frames to one or more additional receiving stations.

[0025] These and other embodiments, including combinations and variations of these embodiments, will be described in additional detail hereafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0027] FIG. 1 is a schematic of a video encoding and decoding system;

[0028] FIG. 2 is a diagram of a video stream;

[0029] FIG. 3 is a method of dynamically changing an encoder's encoding scheme; and

[0030] FIG. 4 is a method of requesting a change in encoding scheme by a receiving station based on resource utilization.

DETAILED DESCRIPTION

[0031] FIG. 1 is a diagram of an encoder and decoder system 10 for still or dynamic video images. An exemplary transmitting station 12 can be, for example, a computer having an internal configuration of hardware including a processor such as a central processing unit (CPU) 14 and a memory 16. CPU 14 is a processor that controls the operations of transmitting station 12. The CPU 14 is connected to memory 16 by, for example, a memory bus. Memory 16 can be random access memory (RAM) or any other suitable memory device. Memory 16 can store data and program instructions which are used by the CPU 14. Other suitable implementations of transmitting station 12 are possible.

[0032] A network 28 connects transmitting station 12 and a receiving station 30 for transmission of an encoded video stream. Specifically, the video stream can be encoded by an encoder in transmitting station 12 and the encoded video stream can be decoded by a decoder in receiving station 30. Network 28 can, for example, be the Internet, which is a packet-switched network. Network 28 can also be a local area network (LAN), wide area network (WAN), virtual private network (VPN), or any other means of transferring the video stream from transmitting station 12.

[0033] The transmission of the encoded video stream can be accomplished using a real-time protocol, such as the real-time transport protocol (RTP), as described in Request for

Comments (RFC) # 3550. Control of the transmission can be accomplished using the real-time transport control protocol (RTCP).

[0034] Receiving station 30, in one example, can be a computer having an internal configuration of hardware including a processor such as a central processing unit (CPU) 32 and a memory 34. CPU 32 is a controller for controlling the operations of receiving station 30. CPU 32 can be connected to memory 34 by, for example, a memory bus. Memory 34 can be RAM or any other suitable memory device. Memory 34 stores data and program instructions that are used by CPU 32. Other suitable implementations of receiving station 30 are possible.

[0035] A display 36 configured to display a video stream is connected to receiving station 30. Display 36 can be implemented in various ways, including by a liquid crystal display (LCD) or a cathode-ray tube (CRT). The display 36 can be configured to display a rendering of the video stream decoded by the decoder in receiving station 30.

[0036] Real-time reception, decoding, and rendering require a certain amount of computational resources, depending on the encoding scheme used. If the amount of computational resources needed to receive, decode, and render is not available on the receiving station, playback of video can be delayed or degraded.

[0037] Other implementations of the encoder and decoder system 10 are possible. In one implementation, for example, additional components can be added to the encoder and decoder system 10. For example, a display or a video camera can be attached to transmitting station 12 to capture the video stream to be encoded. In another implementation, for example, a transport protocol other than RTP can be used.

[0038] FIG. 2 is a diagram a typical video stream 50 to be encoded and decoded. Video coding formats, for example, VP8 or H.264, provide a defined hierarchy of layers for video stream 50. Video stream 50 includes a video sequence 52. At the next level, video sequence 52 consists of a number of adjacent frames 54, which can then be further subdivided into a single frame 56. At the next level, frame 56 can be divided into a series of blocks 58, which can contain data corresponding to, for example, a 16x16 block of displayed pixels in frame 56. Each block can contain luminance and chrominance data for the corresponding pixels. Blocks 58 can also be of any other suitable size such as 16x8 pixel groups or 8x16 pixel groups.

[0039] FIG. 3 is a method 70 of dynamically changing an encoder's encoding scheme. First, at stage 72, the encoder encodes the next available frame in a video stream using a first

encoding scheme. An encoding scheme is any set of parameters and techniques used to encode a video stream. In one example, different encoding schemes can be used to achieve encoded video streams having different levels of compression. In another example, video streams encoded using different encoding schemes can require a different amount of computing resources to decode, based on the encoding scheme used. Parameters such as resolution and frame rate can be varied in different encoding schemes to adjust the amount of computing resources needed for decoding.

[0040] At stage 74, the frame encoded using the first encoding scheme is transmitted to the receiving station. At stage 76, the encoder checks to see if a signal has been received from the receiving station requesting a change in encoding scheme. The signal will be generated by the receiving station if the receiving station's resource utilization exceeds a threshold. If a signal is not received, control will return to stage 72 to encode the next frame in the video stream and to transmit it to the receiving station.

[0041] Otherwise, if a signal is received, the encoder will encode the remaining frames in the video stream using a second encoding scheme at stage 78. Once encoded, the frames are transmitted. The second encoding scheme requires less resources to decode than the first encoding scheme. The second encoding scheme can be requested by the receiving station using the signal or it can be selected by the encoder. In one example, the receiving station can request a second encoding scheme that encodes the video stream at a lower resolution. In another example, the receiving station can request a second encoding scheme that encodes the video stream at a lower frame rate. Other attributes of the second encoding scheme can also be requested or selected.

[0042] The stages shown in FIG. 3 are illustrative, and stages can be added, omitted, or modified in various implementations. For example, stage 78 can be adapted so that a second signal received from the receiving station can trigger encoding using another encoding scheme. In another example, a stage can be added before encoding begins to negotiate the first encoding scheme between the encoder and the receiving station. Other variations are also possible.

[0043] In another implementation, there can be multiple receiving stations. In this case, a transmitting station would encode and transmit the same encoded video stream to each of the receiving stations. If one of the receiving stations, for example, sent a signal for encoding to be switched to another encoding scheme, the change in encoding scheme by the encoder would

affect encoded video stream received by all of the receiving stations. In an alternative implementation, a request for a different encoding scheme by one receiving station would not affect the encoded video stream received by the other receiving stations. In other words, the encoder would encode more than one encoded video stream, each encoded video stream intended for one or more of the receiving stations.

[0044] FIG. 4 is a method 90 of requesting a change in encoding scheme by a receiving station based on resource utilization. At stage 92, the receiving station receives the next frame of an encoded video stream from the transmitting station. The next frame can be encoded using a variety of encoding schemes. In one example, the next frame can be encoded using a first encoding scheme that is the original encoding scheme used to encode the video stream. Alternatively, the next frame can be encoded using a second encoding scheme that is an encoding scheme requested by the receiving station.

[0045] At stage 94, the received frame is processed. Processing can include various operations, such as buffering, decoding, and rendering. In some implementations, processing can include saving the decoded video stream to a file. At stage 96, the resource utilization of the receiving station is determined. The resource utilization measurement determination includes decoding related utilization and non-decoding related utilization of the receiving station's resources. Resource utilization can include measurements such as processor (i.e. CPU) utilization, memory utilization, graphics card utilization, and display resolution. Resource utilization can represent the utilization as measured at a single point of time, or can represent the average or other aggregate measure of utilization over a period of time.

[0046] In stage 98, the determined resource utilization is compared to a threshold. The threshold can include one or more pre-determined values based on the measurements included in the determined resource utilization. Alternatively, the receiving station can determine the threshold. If the resource utilization exceeds the threshold, control passes to stage 100. At stage 100, a signal is sent to the transmitting station from where the encoded video stream is being transmitted. The signal includes a request to change the encoding scheme of the video stream so that fewer resources are required to decode subsequent encoded frames of the encoded video stream. There can be a delay in between the signal being sent and the receipt of frames encoded using the second encoding scheme.

[0047] Once the signal is sent, or with respect to stage 98, if the threshold is not met, control passes to stage 102. At stage 102, the receiving station determines whether additional frames are available in the encoded video stream. If so, control passes to stage 92 to process the next frame. Otherwise, the method 90 ends.

[0048] With respect again to stage 98, if the resource utilization exceeds the threshold, some implementations can use resource management techniques to reduce the resource utilization. Resource management techniques can include, for example, terminating or throttling computing processes on the receiving station that can be stale, non-essential, or not needed. Another example includes employing garbage collection techniques to free up available memory resources on the receiving stations. Numerous other resource management techniques can be employed in various implementations.

[0049] With respect again to stage 100, the signal can request a new encoding scheme specifically. For example, the signal can request that the new encoding scheme produce an encoded video stream at a lower resolution or at a lower frame rate. In other implementations, the signal can request various attributes and permutations of encoding schemes including, for example, monochrome encoding, quantization levels, or encoding standards. Other encoding scheme attributes can be used in other implementations.

[0050] In one implementation, the measured resource can be the resolution of frames in the encoded video stream, with the threshold being the resolution of the receiving station's display. In this example, if the video stream resolution exceeds the display resolution, resources are being used to decode video that cannot be fully displayed on the receiving station. Therefore, the receiving station will request a new encoding scheme where the encoded video stream is encoded at the resolution of the receiving station's display. In this context, the display resolution can be that of the entire display, or a portion thereof (i.e. a window) that the video is being rendered within.

[0051] The operations of encoding and decoding can be performed in many different ways and can produce a variety of encoded data formats. The above-described embodiments of encoding or decoding can illustrate some exemplary encoding techniques. However, in general, encoding and decoding are understood to include any transformation or any other change of data whatsoever.

[0052] The embodiments of transmitting station 12 and/or receiving station 30 (and the algorithms, methods, instructions etc. stored thereon and/or executed thereby) can be realized in any computing device having hardware, software, or any combination thereof including, for example, IP cores, ASICS, programmable logic arrays, optical processors, programmable logic controllers, microcode, firmware, microcontrollers, servers, microprocessors, digital signal processors or any other suitable circuit. In the claims, the term "processor" should be understood as encompassing any the foregoing, either singly or in combination. The terms "signal" and "data" are used interchangeably. Further, portions of transmitting station 12 and receiving station 30 do not necessarily have to be implemented in the same manner.

[0053] Further, in one embodiment, for example, transmitting station 12 or receiving station 30 can be implemented using a general purpose computer/processor with a computer program that, when executed, carries out any of the respective methods, algorithms and/or instructions described herein. In addition or alternatively, for example, a special purpose computer/processor can be utilized which can contain specialized hardware for carrying out any of the methods, algorithms, or instructions described herein.

[0054] Transmitting station 12 and receiving station 30 can, for example, be implemented on computers in a screencasting or a videoconferencing system. Alternatively, transmitting station 12 can be implemented on a server and receiving station 30 can be implemented on a device separate from the server, such as a hand-held communications device (i.e. a cell phone). In this instance, transmitting station 12 can encode content using an encoder into an encoded video signal and transmit the encoded video signal to the communications device. In turn, the communications device can then decode the encoded video signal using a decoder. Alternatively, the communications device can decode content stored locally on the communications device (i.e. no transmission is necessary). Other suitable transmitting station 12 and receiving station 30 implementation schemes are available. For example, receiving station 30 can be a personal computer rather than a portable communications device.

[0055] Further, all or a portion of embodiments of the present invention can take the form of a computer program product accessible from, for example, a computer-usable or computer-readable medium. A computer-usable or computer-readable medium can be any device that can, for example, tangibly contain, store, communicate, or transport the program for use by

or in connection with any processor. The medium can be, for example, an electronic, magnetic, optical, electromagnetic, or a semiconductor device. Other suitable mediums are also available.

[0056] The above-described embodiments have been described in order to allow easy understanding of the present invention and do not limit the present invention. On the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structure as is permitted under the law.

What is claimed is:

1. A method for decoding a video stream, the video stream having a plurality of frames, the method comprising:

receiving one or more initial encoded frames of the plurality of frames from a transmitting station, the one or more initial encoded frames encoded using a first encoding scheme;

processing the one or more initial encoded frames using a computing device;

determining the resource utilization of the computing device; and

if the resource utilization exceeds a threshold, sending a request to the transmitting station to encode frames of the plurality of frames using a second encoding scheme that requires fewer resources to decode.

2. The method of claim 1, wherein the resource utilization includes at least one of processor utilization, memory utilization, or graphics card utilization.

3. The method of claim 1 or claim 2, further comprising:

reducing the computing device's resource utilization by using resource management techniques.

4. The method of claim 3, wherein the resource management techniques comprise:

reducing non-decoding-related processes.

5. The method of claim 1 or claim 2, wherein the processing includes rendering frames for display on a device configured to display the frames at a specified resolution, wherein the threshold is determined at least in part by the specified resolution.

6. The method of claim 5, wherein the second encoding scheme includes encoding at the specified resolution.

7. The method of claim 1 or claim 2, wherein the second encoding scheme includes encoding the video stream at a lower resolution or frame rate than the resolution or frame rate at which the video stream is encoded using the first encoding scheme.

8. The method of claim 1 or claim 2, wherein the processing includes any of buffering, decoding, or rendering the initial encoded frames.

9. A computing device for decoding a video stream, the video stream having a plurality of frames, the computing device comprising:

a memory; and

at least one processor configured to execute instructions stored in the memory to:

receive one or more initial encoded frames of the plurality of frames from a transmitting station, the one or more initial encoded frames encoded using a first encoding scheme;

decode the one or more initial encoded frames;

determine the resource utilization of the computing device; and

if the resource utilization exceeds a threshold, send a request to the transmitting station to encode that subsequent encoded frames using a second encoding scheme that requires less computing device resources to decode.

10. The computing device of claim 9, wherein the resource utilization includes at least one of processor utilization, memory utilization, or graphics card utilization.

11. The computing device of claim 9 or claim 10, wherein the second encoding scheme includes instructions to encode the video stream at a lower resolution or frame rate than the resolution or frame rate at which the video stream is encoded using the first encoding scheme.

12. The computing device of claim 9 or claim 10, further comprising instructions to:

attempt to reduce the computing device's resource utilization by using resource management techniques.

13. A method for encoding a video stream, the video stream having a plurality of frames, the method comprising:

encoding one or more initial frames in the plurality of frames using a first encoding scheme;

transmitting the initial encoded frames to a receiving station;

receiving a signal from a receiving station requesting that future frames transmitted to the receiving station be encoded using a second encoding scheme that requires fewer resources for decoding;

encoding one or more subsequent frames from the plurality of frames using the second encoding scheme; and

transmitting the subsequent encoded frames to the receiving station.

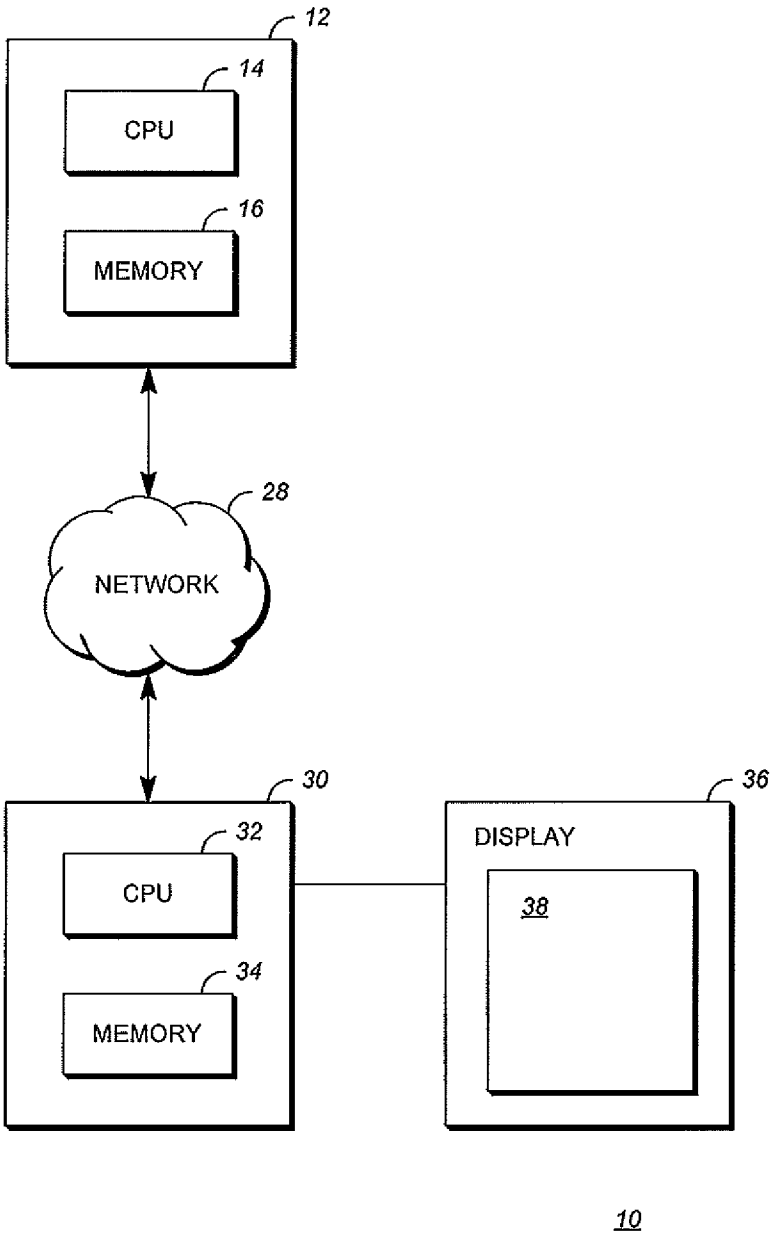
12
14
CPU
16
MEMORY
28
NETWORK
30
32
CPU
34
MEMORY
36
DISPLAY
38
10

FIG. 1

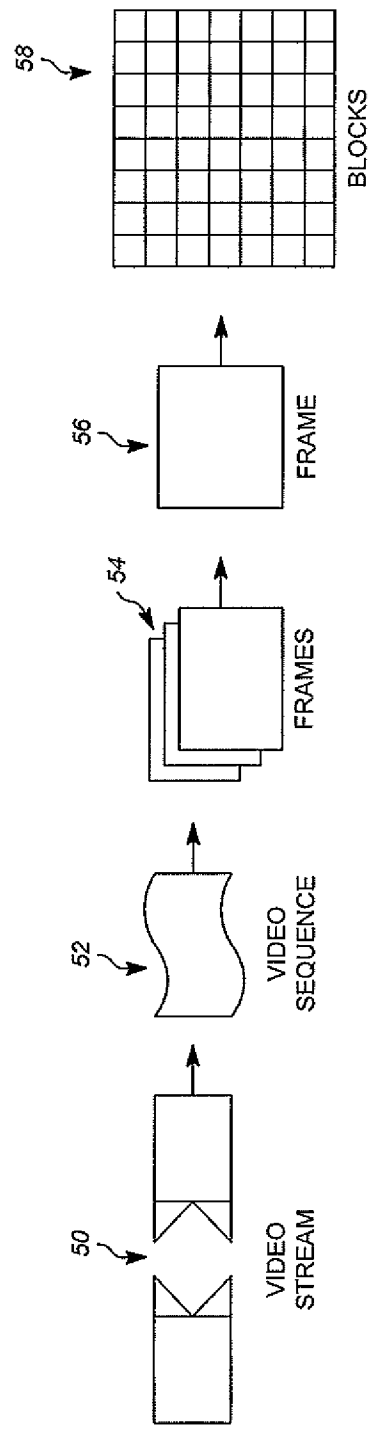
58
BLOCKS
56
FRAME
54
FRAMES
52
VIDEO SEQUENCE
50
VIDEO STREAM

FIG. 2

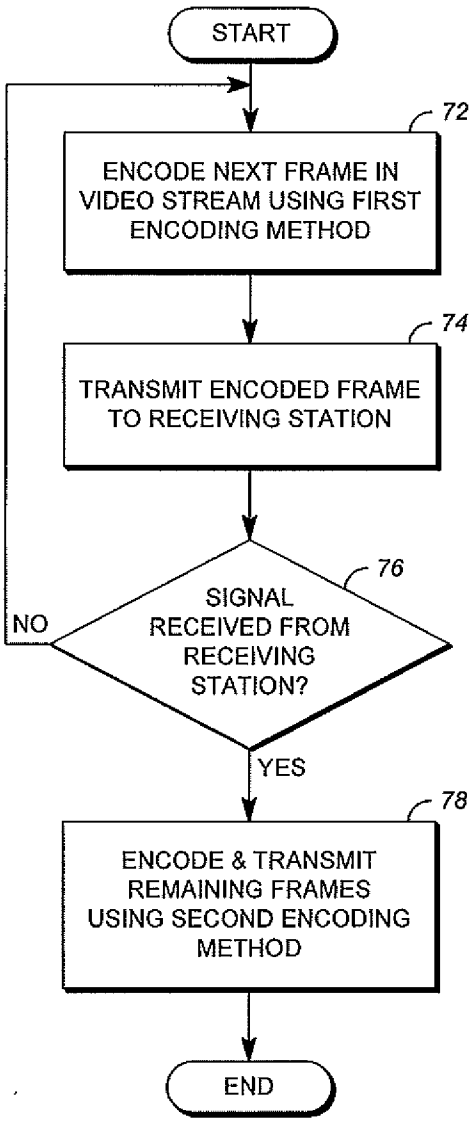
START
72
70
ENCODE NEXT FRAME IN VIDEO STREAM USING FIRST ENCODING METHOD
74
TRANSMIT ENCODED FRAME TO RECEIVING STATION
76
SIGNAL RECEIVED FROM RECEIVING STATION?
NO
YES
78
ENCODE & TRANSMIT REMAINING FRAMES USING SECOND ENCODING METHOD
END

FIG. 3

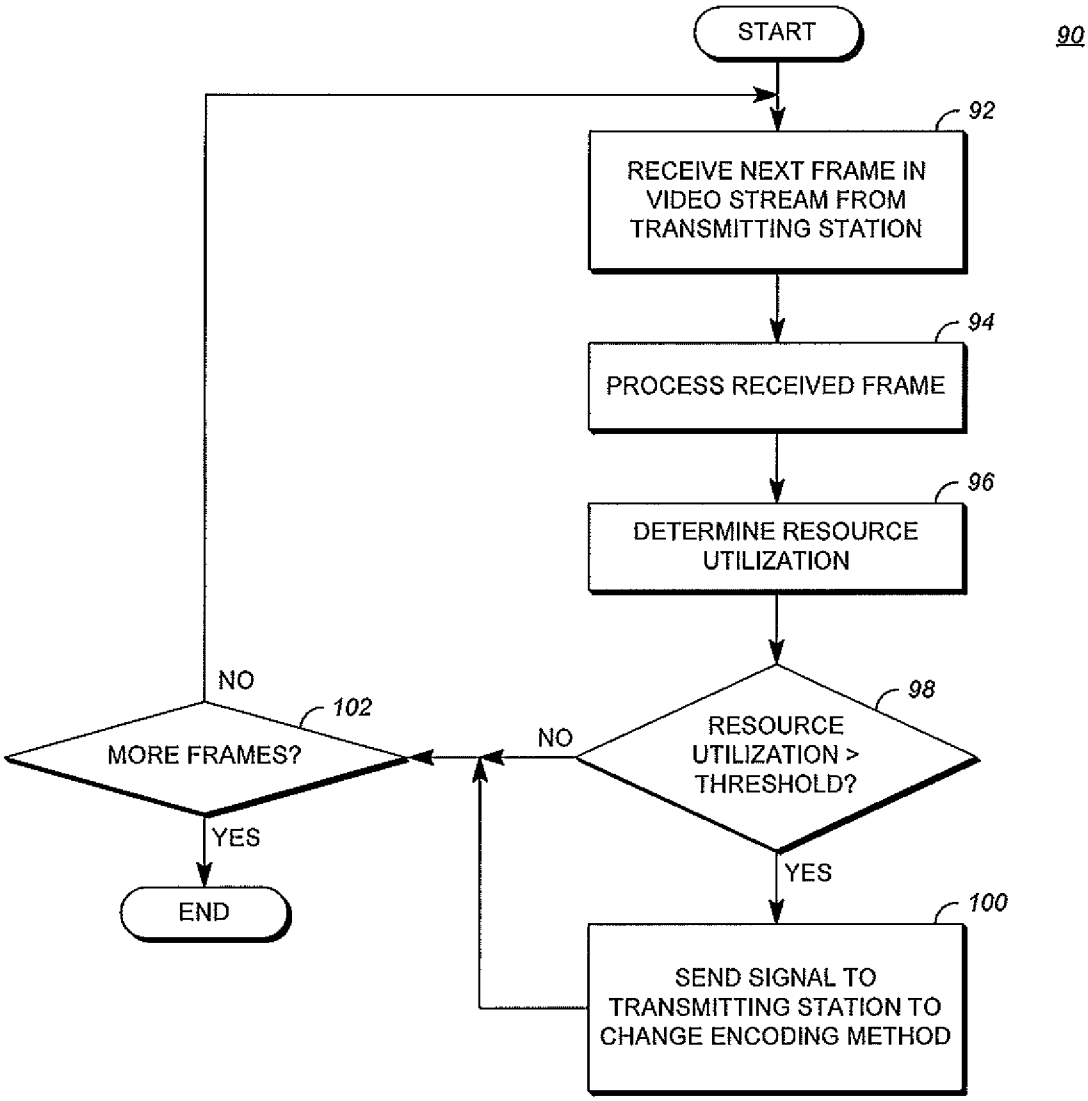
START
90
92
RECEIVE NEXT FRAME IN VIDEO STREAM FROM TRANSMITTING STATION
94
PROCESS RECEIVED FRAME
96
DETERMINE RESOURCE UTILIZATION
98
RESOURCE UTILIZATION > THRESHOLD?
NO
YES
100
SEND SIGNAL TO TRANSMITTING STATION TO CHANGE ENCODING METHOD
102
MORE FRAMES?
NO
YES
END

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/035506

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N21/6373 H04N21/442 H04N21/6379
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 7 310 811 B1 (BASSO ANDREA [US] ET AL) 18 December 2007 (2007-12-18) abstract column 2, line 37 - column 4, line 21 figures 2,3	1,2, 7-11,13 3,4,12

X	WO 03/053040 A2 (THOMSON LICENSING SA [FR]; CAHNBLEY JENS [US]; RICHARDSON JOHN WILLIAM) 26 June 2003 (2003-06-26) abstract page 3, line 23 - page 10, line 16 figures 2-4	1,2, 5-11,13

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 January 2012	24/01/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hampson, Frances

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/035506

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/167472 A1 (BARBANSON MONIQUE [US] ET AL) 4 September 2003 (2003-09-04) abstract paragraph [0011] paragraph [0030] - paragraph [0031] paragraph [0040] - paragraph [0047] figures 3-5	1,2, 5-11,13
Y	WO 01/84301 A2 (MICROSOFT CORP [US]) 8 November 2001 (2001-11-08)	3,4,12
A	abstract page 31, line 9 - page 33, line 10 figures 6-8	1,9
A	US 2010/303146 A1 (KAMAY YANIV [IL]) 2 December 2010 (2010-12-02) abstract paragraph [0062] - paragraph [0067] figures 6,7	1-13
A	US 2010/235520 A1 (ATTANASIO LUISA [IT] ET AL) 16 September 2010 (2010-09-16) abstract paragraph [0011] - paragraph [0026] figure 1	1-13

INTERNATIONAL SEARCH REPORT

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