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(54) **NETWORK MANAGED CHANNEL CHANGE IN DIGITAL NETWORKS**

(76) Inventor: **Kumar Ramaswamy**, Princeton, NJ (US)

Correspondence Address:
Joseph J. Laks
Thomson Licensing LLC
2 Independence Way, Patent Operations
PO Box 5312
PRINCETON, NJ 08543 (US)

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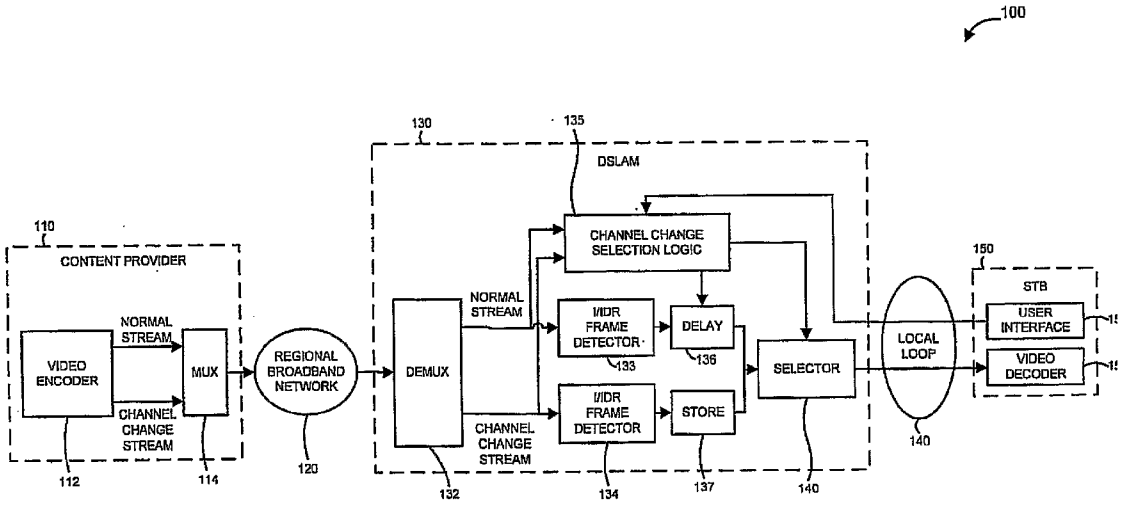
(57) **ABSTRACT**

There are provided a circuit and corresponding method for enabling a channel change in a digital network. The circuit has inputs for receiving a channel change stream and a normal stream. The circuit further includes a multiplexer, a memory device, and a picture element detector. The multiplexer is for transmitting the channel change stream to a customer premises equipment (CPE) device in response to a channel change request from the CPE device. The memory device is for storing a flag that is set in response to the channel change request from the CPE device. The flag is set to request detection of a picture element in the normal stream. The picture element detector is for detecting the picture element in the normal stream subsequent to transmitting the channel change stream. The multiplexer transmits the normal stream to the CPE device in place of the channel change stream once the picture element is detected in the normal stream.



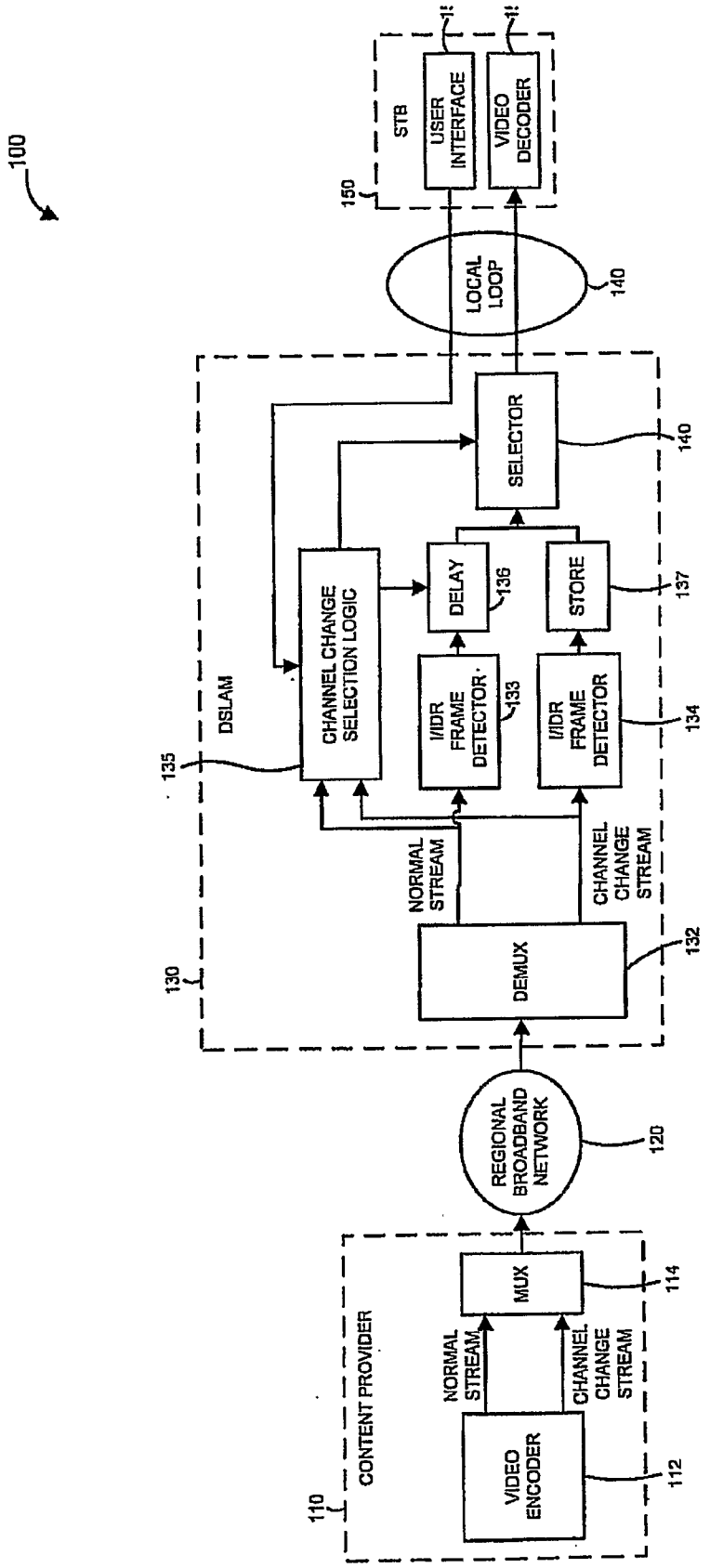

100
CONTENT PROVIDER
110
VIDEO ENCODER
112
NORMAL STREAM
CHANNEL CHANGE STREAM
MUX
114
REGIONAL BROADBAND NETWORK
120
DSLAM
130
DEMUX
132
NORMAL STREAM
CHANNEL CHANGE STREAM
135
CHANNEL CHANGE SELECTION LOGIC
I/IDR FRAME DETECTOR
133
I/IDR FRAME DETECTOR
134
DELAY
136
STORE
137
SELECTOR
140
LOCAL LOOP
140
STB
150
USER INTERFACE
VIDEO DECODER

FIG. 1

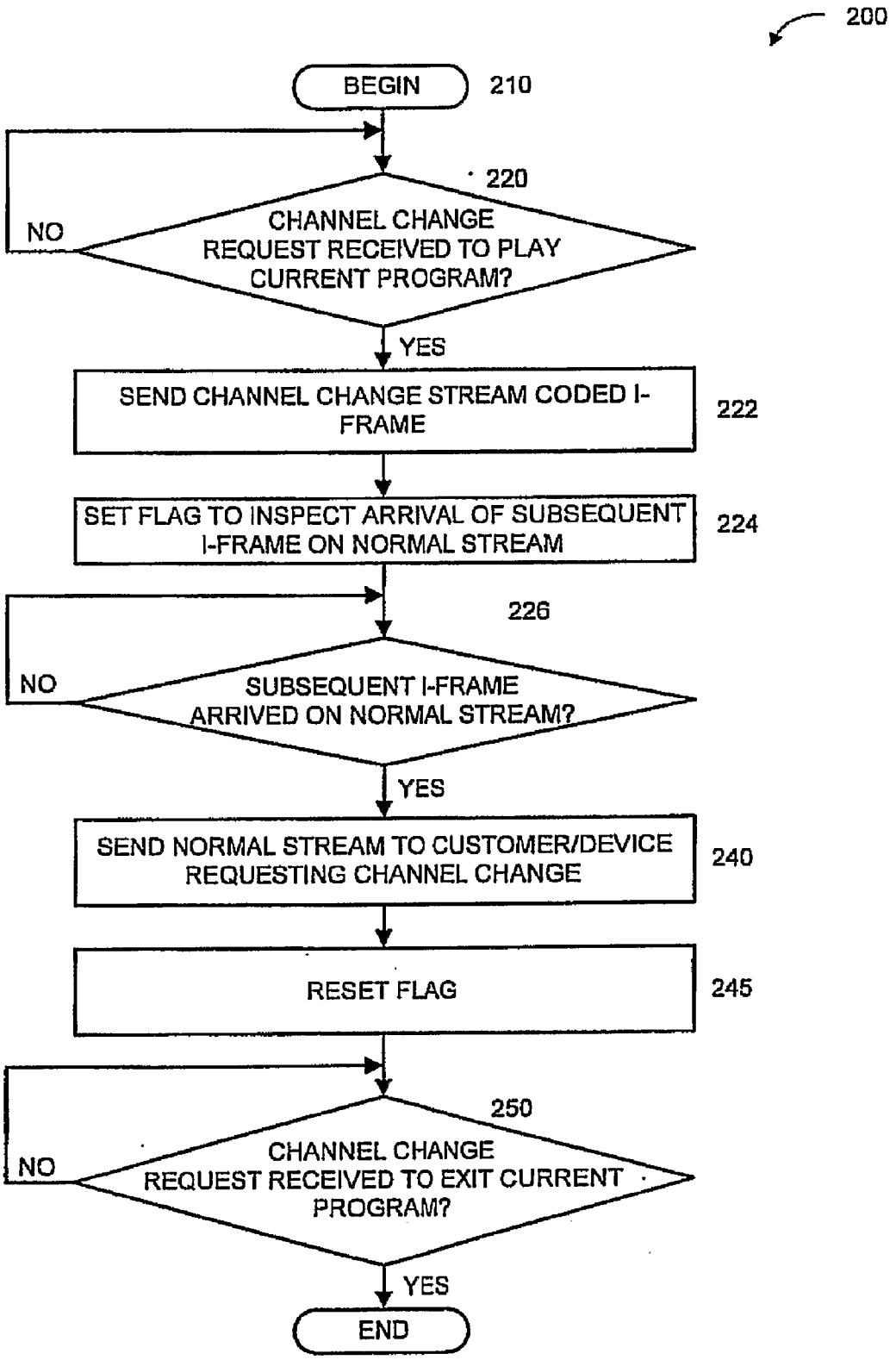

200
BEGIN
210
220
CHANNEL CHANGE REQUEST RECEIVED TO PLAY CURRENT PROGRAM?
NO
YES
SEND CHANNEL CHANGE STREAM CODED I-FRAME
222
SET FLAG TO INSPECT ARRIVAL OF SUBSEQUENT I-FRAME ON NORMAL STREAM
224
226
SUBSEQUENT I-FRAME ARRIVED ON NORMAL STREAM?
NO
YES
SEND NORMAL STREAM TO CUSTOMER/DEVICE REQUESTING CHANNEL CHANGE
240
RESET FLAG
245
250
CHANNEL CHANGE REQUEST RECEIVED TO EXIT CURRENT PROGRAM?
NO
YES
END

FIG. 2

NETWORK MANAGED CHANNEL CHANGE IN DIGITAL NETWORKS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 60/633,475, filed Dec. 6, 2004, which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates generally to digital networks and, more particularly, to a method and apparatus for enabling a channel change in a digital network.

BACKGROUND OF THE INVENTION

[0003] In a Digital Subscriber Line (DSL) multicast/broadcast video system, Internet Protocol (IP) multicast can be used to transmit compressed video to a set-top box (STB). The Internet Group Management Protocol (IGMP) is a mechanism to select which channel to watch, by sending a join request for the desired channel to a Digital Subscriber Line Access Multiplexer (DSLAM). When that channel is no longer desired, a leave request can be sent to the DSLAM.

[0004] In a commercial video over DSL broadcast system, it is desirable to allow end users to be able to change channels rapidly. Popular video compression standards, such as MPEG-2 and JVT/H.264/MPEG AVC use intra and inter coding. For proper decoding, a decoder must decode a compressed video sequence beginning with an intra-coded (I) picture or instantaneous decoder refresh (IDR) picture or an I-slice, and then continuing to decode the subsequent inter-coded (P and B) pictures. A Group of Pictures (GOP) may include at least one I-picture and at least one P and/or B picture. I-pictures typically require many more bits to code than a P or B picture of equivalent video quality, often in the range of 3-10 times as many bits.

[0005] When a receiver initially begins receiving a program on a particular channel, following a channel change or upon the initial turning on of the receiver, the receiver must wait until an I-picture is received to begin decoding properly, which causes a delay.

[0006] To minimize channel change delay in digital video broadcast systems, I-pictures are typically sent frequently, e.g., every N pictures. For example, to enable a ½ second delay (of the video compression portion of the system), it is common to use N=15 for 30 fps content. Since compressed I-pictures are much larger than compressed P and B pictures, this considerably increases the bitrate over what would be required if I-pictures were not inserted so frequently.

[0007] In a first prior art system, a channel change stream was encoded and transmitted along with the normal video bitstream. The channel change stream included lower quality I-pictures that were sent at a higher frequency than I-pictures in the normal bitstream. When a user tuned to a new channel, playback could begin upon receipt of the first I-pictures, in either the normal or channel change stream.

[0008] In a second prior art system, for each program, a relatively low bitrate, low resolution channel change stream is encoded, in addition to the normal coded stream. When a channel change request is received at the Customer Premises Equipment (CPE), join request are made to both the channel change stream and the normal stream of the newly selected program and both streams are sent down the DSL link. The CPE then appropriately makes the switchover from the channel change stream to the normal stream.

[0009] Since the solution in the second prior art system above calls for both the normal and channel change stream to be sent over the DSL link when a channel change request is made, it will result in increased bandwidth until the CPE initiates a "leave" request on the channel-change stream. For example, a user zapping through HD channels could cause an increased bandwidth usage of a lower resolution (possibly SD resolution) channel.

[0010] Accordingly, it would be desirable and highly advantageous to have a method and apparatus for enabling a channel change in a digital network that overcomes the above-described problems of the prior art.

SUMMARY OF THE INVENTION

[0011] These and other drawbacks and disadvantages of the prior art are addressed by the present invention, which is directed to a method and apparatus for enabling a channel change in a digital network.

[0012] According to an aspect of the present invention, there is provided a circuit for enabling a channel change in a digital network. The circuit has inputs for receiving a channel change stream and a normal stream. The circuit further includes a multiplexer, a memory device, and a picture element detector. The multiplexer is for transmitting the channel change stream to a customer premises equipment (CPE) device in response to a channel change request from the CPE device. The memory device is for storing a flag that is set in response to the channel change request from the CPE device. The flag is set to request detection of a picture element in the normal stream. The picture element detector is for detecting the picture element in the normal stream subsequent to transmitting the channel change stream. The multiplexer transmits the normal stream to the CPE device in place of the channel change stream once the picture element is detected in the normal stream.

[0013] According to another aspect of the present invention, there is provided, in a circuit connected to a digital network and having inputs for receiving a channel change stream and a normal stream, a method for enabling a channel change in the digital network. The method includes the step of transmitting the channel change stream to a customer premises equipment (CPE) device in response to a channel change request from the CPE device. The method also includes the step of setting a flag, in response to the channel change request from the CPE device, to request detection of a picture element in the normal stream. The also further includes the step of detecting the picture element in the normal stream subsequent to transmitting the channel change stream. Moreover, the method includes the step of transmitting the normal stream to the CPE device in place of the channel change stream, once the picture element is detected in the normal stream.

[0014] These and other aspects, features and advantages of the present invention will become apparent from the following detailed description of exemplary embodiments, which is to be read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The present invention may be better understood in accordance with the following exemplary figures, in which:

[0016] FIG. **1** shows a block diagram for an end-to-end architecture in accordance with the principles of the present invention; and

[0017] FIG. **2** shows a flow diagram for a method for enabling a channel change in a Digital Subscriber Line (DSL) system in accordance with the principles of the present invention.

DETAILED DESCRIPTION

[0018] The present invention is directed to a method and apparatus for enabling a channel change in a digital network.

[0019] Advantageously, the present invention improves upon the first and second prior art systems described herein above, overcoming the above-described deficiencies associated therewith. For example, the present invention reduces bandwidth consumption for a Customer Premises Equipment (CPE) initiated, low-delay channel-change mechanism over a Digital Subscriber Loop (DSL) system. In accordance with the principles of the present invention, the request for channel change is made by the CPE. The digital subscriber line access multiplexer (DSLAM) (or some other equipment upstream), in response to this request, switches in a lower-resolution channel-change stream and at an appropriate time later, switches in the full-resolution stream.

[0020] It is to be appreciated that the phrases "customer service equipment" (CPE) and "set top box" (STB) are used interchangeably herein. The term "memoryless picture element" refers to a current picture element that does depend on a preceding picture element or a succeeding picture element. Moreover, it is to be further appreciated that the terms "I-picture" and "memoryless picture element" are used interchangeably herein to refer to any of I-slices, instantaneous decoder refresh (IDR) pictures, or I-pictures.

[0021] Moreover, it is to be appreciated that while the present invention is primarily described herein with respect to a specific example of a digital network, namely a digital subscriber line (DSL) network, given the teachings of the present invention provided herein, one of ordinary skill in the related art may readily apply the present invention to any switched digital network while maintaining the scope of the present invention.

[0022] The present description illustrates the principles of the present invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope.

[0023] All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions.

[0024] Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure.

[0025] Thus, for example, it will be appreciated by those skilled in the art that the block diagrams presented herein represent conceptual views of illustrative circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudocode, and the like represent various processes which may be substantially represented in computer readable media and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

[0026] The functions of the various elements shown in the figures may be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor ("DSP") hardware, read-only memory ("ROM") for storing software, random access memory ("RAM"), and non-volatile storage.

[0027] Other hardware, conventional and/or custom, may also be included. Similarly, any switches shown in the figures are conceptual only. Their function may be carried out through the operation of program logic, through dedicated logic, through the interaction of program control and dedicated logic, or even manually, the particular technique being selectable by the implementer as more specifically understood from the context.

[0028] In the claims hereof, any element expressed as a means for performing a specified function is intended to encompass any way of performing that function including, for example, a) a combination of circuit elements that performs that function or b) software in any form, including, therefore, firmware, microcode or the like, combined with appropriate circuitry for executing that software to perform the function. The invention as defined by such claims resides in the fact that the functionalities provided by the various recited means are combined and brought together in the manner which the claims call for. It is thus regarded that any means that can provide those functionalities are equivalent to those shown herein.

[0029] Advantageously, as noted above, the present invention provides a method and apparatus for enabling a channel change in a digital network including, but not limited to, a digital subscribe line (DSL) network. The present invention provides an improvement over prior art systems such as the second prior art system described above, by minimizing bandwidth consumption in, e.g., a local loop of a DSL network, as compared to the prior art.

[0030] In prior art systems such the second prior art system described above, both the normal and channel change stream are sent over the DSL link (local loop) when a channel change request is made, thereby resulting in a

problem of increased bandwidth until the CPE initiates a "leave" request on the channel-change stream. Advantageously, the present invention solves this problem.

[0031] Turning to FIG. **1**, an exemplary end-to-end architecture to which the present invention may be applied is indicated generally by the reference numeral **100**. The architecture **100** includes a content provider **110**, a regional broadband network **120**, a digital subscriber line access multiplexer (DSLAM) **130**, a local loop **140**, and a set top box (STB) **150**. The content provider **110** includes a video encoder **112** having a first and a second output in signal communication with a first and second input, respectively, of a multiplexer **114**. An output of the multiplexer **114** provides an output of the content provider **110**, which is connected in signal communication with the regional broadband network **120**. The regional broadband network **120** is further connected in signal communication with an input of the DSLAM **130**.

[0032] The DSLAM **130** includes a demultiplexer **132** having a first output in signal communication with an input of an I-picture detector **133** and a second output in signal communication with an input of an I-picture detector **134**. An output of the I-picture detector **133** is connected in signal communication with a first input of channel change selection logic **135** and with a first input of a delay device **136**. An output of the I-picture detector **134** is connected in signal communication with a second input of the channel change selection logic **135** and with an input of a storage device **137**. A first output of the channel change selection logic **135** is connected in signal communication with a second input of the delay device **136**. A second output of the channel change selection logic **135** is connected in signal communication with a first input of a selector **138**. An output of the delay device is connected in signal communication with a second input of the selector **138**. An output of the storage device **137** is connected in signal communication with a third input of the selector **138**.

[0033] A first input of the DSLAM **130** is connected in signal communication with an input of the demultiplexer **132**, a second input of the DSLAM **130** is connected in signal communication with a third input of the selector **138**, and an output of the DSLAM **130** is connected in signal communication with an output of the selector **138**. The second input and the output of the DSLAM **130** are connected in signal communication with the local loop **140**. It is to be appreciated that the DSLAM **130** is also interchangeably referred to herein as a "channel change processing unit".

[0034] The STB **150** includes a user interface **152** and a video decoder **154**. An output of the STB **150** is connected in signal communication with the local loop **140** and with the user interface **152**, and an input of the STB **150** is connected in signal communication with the local loop **140** and with the video decoder **154**.

[0035] The I-picture detectors **133**, **134** are for detecting I-pictures in the normal stream. The delay device **136** is for providing a variable delay.

[0036] The video encoder **112** creates both a normal stream and a channel change stream of coded pictures. The normal stream and channel change stream are multiplexed **114** together and transmitted over a regional broadband network **120** to the DSLAM **130**. For the sake of simplicity with respect to FIG. **1**, only a single program's encoder is shown. In an actual system, multiple programs are supported and, thus, blocks in the figure are duplicated for each supported program. A user makes a channel change request through the user interface **152** in the STB **150**, to indicate a switch to a new program to be viewed. This request is forwarded to the DSLAM **130**.

[0037] In a preferred embodiment of the present invention, the channel change stream is stored in storage local (e.g., local storage device **136**) to the DSLAM **130** (or remote storage which may be quickly accessed by the DSLAM **130**). During normal viewing, the normal stream is transmitted over the local loop **140** to the video decoder **154** at the STB **150**. When a channel change request is initiated by the user interface of the STB **150**, it is sent to the DSLAM **130** through the local loop **140**. Upon receiving the channel change request, the DSLAM **130** begins to send the stored channel change stream of the new program to the STB **150**, beginning with an I-picture in the channel change stream, instead of the normal stream. Then, at a later point, the DSLAM **130** switches back to transmitting the normal stream to the STB **150**.

[0038] Sending the channel change stream in addition to the normal stream increases the bandwidth requirement over the regional broadband network **120**. This increase is bandwidth is sustained until a "leave" request on the channel change stream is initiated by the STB **150**.

[0039] For the purposes of the present invention, it is presumed that the DSLAM (or upstream processing element instrumenting the channel change request, hereinafter referred to as "DSLAM"**130**) is cognizant of the paired normal stream and channel change stream available at its input. Moreover, it is further presumed that the DSLAM **130** is capable of detecting when an I-picture is presented on any input stream, e.g., using I-picture detectors **133**, **134**. When the STB **150** initiates a channel change request, the DSLAM first switches the channel-change stream automatically to the STB **150** at the next available I-picture. The DSLAM then sets a flag to inspect the arrival of the subsequent I-picture on the normal stream. As was described in the first and second prior art systems described above, for bandwidth saving reasons, the channel change stream has more frequent I-picture while the normal stream has less frequent I-pictures. When the subsequent I-picture has arrived on the normal stream, it is switched to serve the customer who made the original request.

[0040] It is to be appreciated that the present invention is more bandwidth efficient in the DSL link (local loop **140**), but does require the DSLAM **130** (or upstream channel change processing element) to keep track of the switch between the channel change and normal stream functions.

[0041] Turning to FIG. **2**, in a Digital Subscriber Line Access Multiplexer (DSLAM) of a DSL system, a method for enabling a channel change is indicated generally by the reference numeral **200**. A begin block **210** passes control to a decision block **220**. The decision block **220** determines whether or not a channel change request has been received to play a current program. If the channel change request has not been received, then control passes back to decision block **220**. Otherwise, if the channel change request has been received, then control passes to a function block **222**. The

function block **222** sends a channel change stream coded I-picture, and passes control to a function block **224**. The function block **224** sets a flag to inspect the arrival of a subsequent I-picture on the normal stream, and passes control to a decision block **226**. The decision block **226** determines whether or not the subsequent I-picture has arrived on the normal stream. If the subsequent I-picture has not yet arrived on the normal stream, then control is returned to decision block **226**. Otherwise, if the subsequent I-picture has arrived on the normal stream, then control is passed to a function block **240**.

[**0042**] The function block **240** sends the normal stream (including the subsequent I-picture) to the individual/device requesting the channel change, and passes control to a function block **245**. The function block **245** resets the flag, and passes control to a decision block **250**. The decision block **250** determines whether or not a channel change request has been received to exit a current program. If the channel change request has not been received, then control passes back to function block **240**. Otherwise, if the channel change request has been received, then control passes to an end block **260**.

[**0043**] These and other features and advantages of the present invention may be readily ascertained by one of ordinary skill in the pertinent art based on the teachings herein. It is to be understood that the teachings of the present invention may be implemented in various forms of hardware, software, firmware, special purpose processors, or combinations thereof.

[**0044**] Most preferably, the teachings of the present invention are implemented as a combination of hardware and software. Moreover, the software is preferably implemented as an application program tangibly embodied on a program storage unit. The application program may be uploaded to, and executed by, a machine comprising any suitable architecture. Preferably, the machine is implemented on a computer platform having hardware such as one or more central processing units ("CPU"), a random access memory ("RAM"), and input/output ("I/O") interfaces. The computer platform may also include an operating system and microinstruction code. The various processes and functions described herein may be either part of the microinstruction code or part of the application program, or any combination thereof, which may be executed by a CPU. In addition, various other peripheral units may be connected to the computer platform such as an additional data storage unit and a printing unit.

[**0045**] It is to be further understood that, because some of the constituent system components and methods depicted in the accompanying drawings are preferably implemented in software, the actual connections between the system components or the process function blocks may differ depending upon the manner in which the present invention is programmed. Given the teachings herein, one of ordinary skill in the pertinent art will be able to contemplate these and similar implementations or configurations of the present invention.

[**0046**] Although the illustrative embodiments have been described herein with reference to the accompanying drawings, it is to be understood that the present invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one of ordinary skill in the pertinent art without departing from the scope or spirit of the present invention. All such changes and modifications are intended to be included within the scope of the present invention as set forth in the appended claims.

1. A circuit for enabling a channel change in a digital network, the circuit having inputs for receiving a channel change stream and a normal stream, the circuit further comprising:

a multiplexer for transmitting the channel change stream to a customer premises equipment (CPE) device in response to a channel change request from the CPE device;

a memory device for storing a flag that is set in response to the channel change request from the CPE device, the flag being set to request detection of a picture element in the normal stream; and

a picture element detector for detecting the picture element in the normal stream subsequent to transmitting the channel change stream,

wherein said multiplexer transmits the normal stream to the CPE device in place of the channel change stream once the picture element is detected in the normal stream.

2. The circuit according to claim 1, wherein the picture element is a memoryless picture element.

3. The circuit according to claim 1, wherein the channel change stream includes more picture elements than the normal stream.

4. The circuit according to claim 1, wherein the flag stored in the memory device is reset, when the picture element is detected in the normal stream.

5. The circuit according to claim 1, further comprising a variable delay device for delaying the normal stream prior to a transmission of the normal stream from the multiplexer to the CPE device.

6. The circuit according to claim 1, wherein the circuit is implemented in a digital subscriber line access modem (DLSAM).

7. The circuit according to claim 1, wherein the digital network is a digital subscriber line (DSL) network.

8. The circuit according to claim 1, wherein the picture element comprises any of an I-slice, an I-picture, and an instantaneous decoder refresh (IDR) picture.

9. In a circuit connected to a digital network and having inputs for receiving a channel change stream and a normal stream, a method for enabling a channel change in the digital network, the method comprising the steps of:

transmitting the channel change stream to a customer premises equipment (CPE) device in response to a channel change request from the CPE device;

setting a flag, in response to the channel change request from the CPE device, to request detection of a picture element in the normal stream;

detecting the picture element in the normal stream subsequent to transmitting the channel change stream; and

transmitting the normal stream to the CPE device in place of the channel change stream, once the picture element is detected in the normal stream.

10. The method according to claim 9, wherein said picture element is a memoryless picture element.

11. The method according to claim 9, wherein the channel change stream includes more picture elements than the normal stream.

12. The method according to claim 9, further comprising the step of resetting the flag, when the picture element is detected in the normal stream.

13. The method according to claim 9, further comprising the step of delaying the normal stream prior to a transmission of the normal stream from the circuit to the CPE device.

14. The method according to claim 9, wherein the circuit is implemented in a digital subscriber line access modem (DLSAM).

15. The method according to claim 9, wherein the digital network is a digital subscriber line (DSL) network.

16. The method according to claim 9, wherein the picture element comprises any of an I-slice, an I-picture, and an instantaneous decoder refresh (IDR) picture.

* * * * *