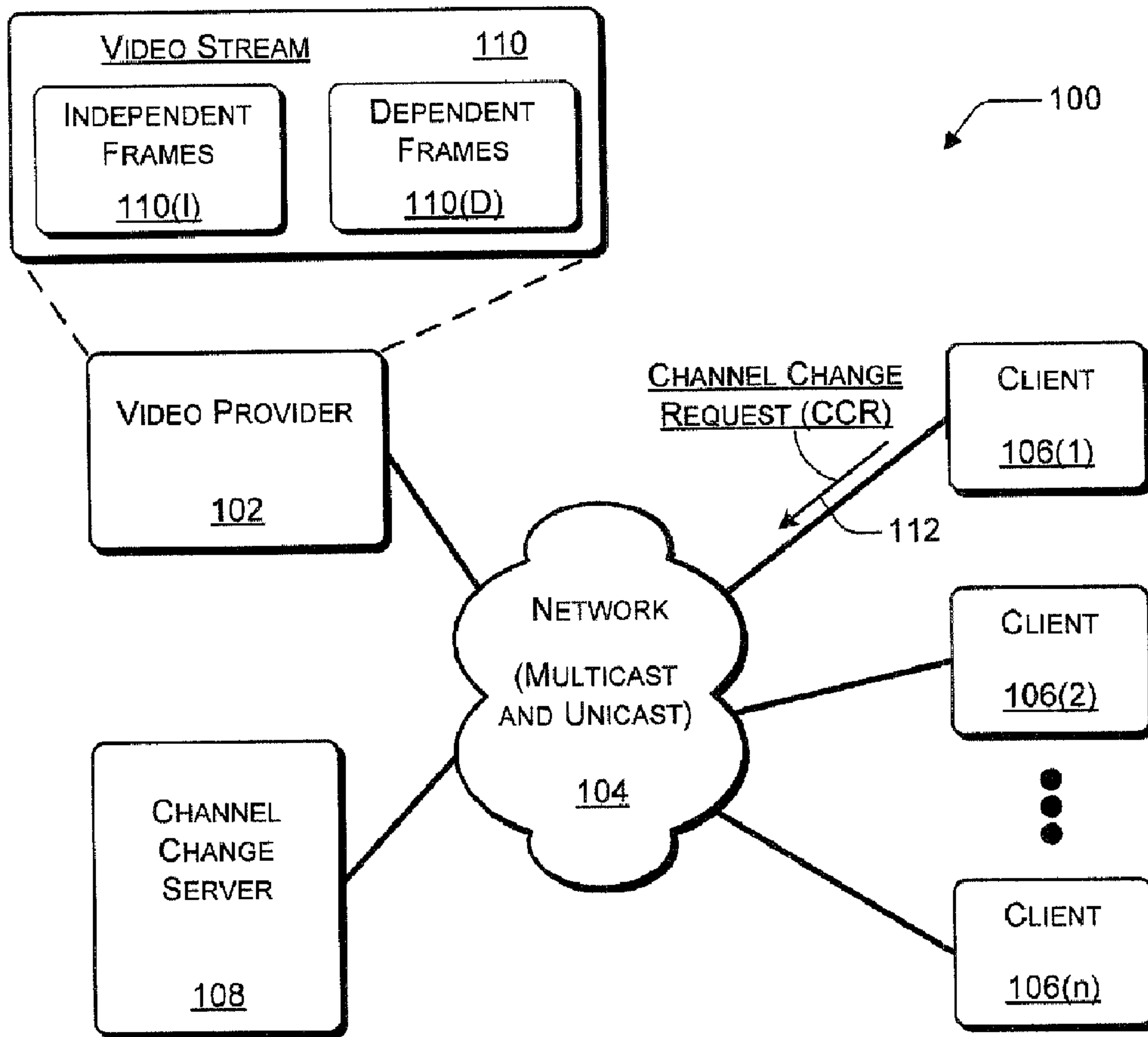




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(57) Abrégé/Abstract:

In an exemplary server implementation, a server is configured to retain at least one independent frame for each video channel of multiple video channels that are being distributed using multicast communications and is adapted to respond to channel change



(57) **Abrégé(suite)/Abstract(continued):**

requests from clients by transmitting the retained at least one independent frame of a requested video channel to a requesting client using a unicast communication. In an exemplary method implementation, a method for fast channel changing in a multicast video distribution architecture includes: detecting a channel change request that indicates a requested channel, the requested channel corresponding to a multicast group; and transmitting a retained intra frame for the requested channel as a unicast communication.

1
2 **ABSTRACT**

3 In an exemplary server implementation, a server is configured to retain at
4 least one independent frame for each video channel of multiple video channels that
5 are being distributed using multicast communications and is adapted to respond to
6 channel change requests from clients by transmitting the retained at least one
7 independent frame of a requested video channel to a requesting client using a
8 unicast communication. In an exemplary method implementation, a method for
9 fast channel changing in a multicast video distribution architecture includes:
10 detecting a channel change request that indicates a requested channel, the
11 requested channel corresponding to a multicast group; and transmitting a retained
12 intra frame for the requested channel as a unicast communication.

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Fast Channel Change

TECHNICAL FIELD

This disclosure relates in general to changing channels in a digital video environment and in particular, by way of example but not limitation, to reducing the video presentation latency when changing from one video channel to another video channel in a digital multicast network.

BACKGROUND

Television-based entertainment systems are expanding the programming and services that they offer. In addition to television programming content such as that found on broadcast and traditional cable networks, television service providers are adding on-demand video, as well as other interactive services, features, and applications. The existence of these specific services, features, and applications, as well as the continuing increase in the breadth of available general programming content, drives the adoption of digital network technology for television-based entertainment systems.

Digital technology enables satellite and cable operators to increase the number and kinds of services that they offer to subscribers and thus their average revenue per subscriber. Unfortunately, although digital technology offers many advantages to subscribers as compared to traditional analog networks, it also has a number of drawbacks. For example, changing channels in a digital television service typically takes longer than in an analog television service. This channel changing latency annoys and frustrates users of the digital television service.

1 This channel changing latency and other drawbacks of digital technology
2 lead to higher rates of subscriber churn, which means that a large percentage of
3 subscribers that try digital television service switch back to traditional analog
4 service within a short time period. Switching subscribers from analog to digital
5 service involves expenditures for network operators that range from broad, general
6 marketing costs down to individual incentives and installation expenses.
7 Furthermore, network operators usually have greater opportunity and/or ability to
8 sell add-on services (e.g., extra channels, pay-per-view, etc.) in conjunction with
9 digital network services. Consequently, reducing subscriber churn can financially
10 benefit satellite and cable operators.

11 Accordingly, for e.g. television-based entertainment systems, there is a
12 need for schemes and/or techniques to reduce the churn out of digital service and
13 back to traditional analog service that results from subscribers being dissatisfied
14 with the slower channel changing experienced with digital television service.

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SUMMARY

According to one broad aspect of the invention, there is provided a method for fast channel changing in a multicast video distribution architecture, the method comprising: buffering a multicast video stream segment at a server, the buffered multicast video stream segment including a first retained intra frame and a second retained intra frame, the first retained intra frame being before the second retained intra frame in the buffered multicast video stream segment; detecting a channel change request that indicates a requested channel, the channel change request being from a requesting device, the requested channel corresponding to the buffered multicast video stream segment; determining whether a first next decodable non-intra frame after the first retained intra frame is at least a joining time after a send point of the buffered multicast video stream segment; in response to detecting the channel change request, transmitting to the requesting device a retained intra frame and no dependent frames for the requested channel as a unicast communication for static display, wherein, if the first next decodable non-intra frame after the first retained intra frame is determined to be at least the joining time after the send point of the buffered multicast video stream segment, then the transmitted retained intra frame is the first retained intra frame and the first next decodable non-intra frame after the first retained intra frame is a joining frame, and wherein if the first next decodable non-intra frame after the first retained intra frame is determined to be less than the joining time after the send point of the buffered multicast video stream segment, then the transmitted retained intra frame is the second retained intra frame and a second next decodable non-intra frame after the second retained intra frame is the joining frame; and synchronizing a multicast joining operation to a multicast group corresponding to the requested channel, wherein synchronizing includes ensuring the joining frame is the oldest non-intra frame of the buffered multicast video stream segment received by the requesting device in response to the channel change request after the multicast joining operation.

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According to another broad aspect of the invention, there is provided a method for fast channel changing in a multicast video distribution architecture, the method comprising: sending a channel change request to a server, the channel change request indicating a requested channel, the server buffering a multicast video stream segment, the buffered multicast video stream segment including a first retained intra frame and a second retained intra frame, the first retained intra frame being before the second retained intra frame in the buffered multicast video stream segment, the requested channel corresponding to a multicast group and the buffered multicast video stream segment corresponding to the requested channel, wherein the server determines whether a first next decodable non-intra frame after the first retained intra frame is at least a joining time after a send point of the buffered multicast video stream segment; in response to sending the channel change request, receiving a retained intra frame for the requested channel as a unicast communication, wherein if the first next decodable non-intra frame after the first retained intra frame is determined to be at least the joining time after the send point of the buffered multicast video stream segment, then the transmitted retained intra frame is the first retained intra frame and the first next decodable non-intra frame after the first retained intra frame is a joining frame, and wherein if the first next decodable non-intra frame after the first retained intra frame is determined to be less than the joining time after the send point of the buffered multicast video stream segment, then the transmitted retained intra frame is the second retained intra frame and a second next decodable non-intra frame after the second retained intra frame is the joining frame; statically displaying the received retained intra frame; receiving as a multicast communication a portion of the multicast video stream corresponding to the requested channel, wherein the initial multicast frame of the multicast video stream received is the joining frame, the portion including a plurality of consecutive multicast frames of the multicast video stream; and switching from statically displaying the received retained intra frame to displaying the portion of the multicast video stream.

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According to yet another broad aspect of the invention, there is provided one or more non-transitory processor-readable storage media having processor-executable instructions stored thereon, the instructions that, when executed, causing an apparatus to perform the methods described herein.

5 In an exemplary server implementation, a server is configured to retain at least one independent frame for each video channel of multiple video channels that are being distributed using multicast communications and is adapted to respond to channel change requests from clients by transmitting the retained at least one independent frame of a requested video channel to a requesting client using a
10 unicast communication. In an exemplary method implementation, a method for fast channel changing in a multicast video distribution architecture includes: detecting a channel change request that indicates a requested channel, the

1 requested channel corresponding to a multicast group; and transmitting a retained
2 intra frame for the requested channel as a unicast communication.

3 Other method, system, approach, apparatus, server, device, media,
4 procedure, arrangement, etc. implementations are described herein.

5 6 **BRIEF DESCRIPTION OF THE DRAWINGS**

7 The same numbers are used throughout the drawings to reference like
8 and/or corresponding aspects, features, and components.

9 FIG. 1 illustrates an exemplary video distribution architecture that includes
10 a network that is capable of both multicast and unicast communications.

11 FIG. 2 illustrates a video distribution architecture that includes an
12 exemplary channel change server that is capable of providing an intra frame in a
13 unicast message.

14 FIG. 3A illustrates a video distribution architecture that includes an
15 exemplary channel change server that is capable of synchronizing a joining to a
16 multicast group for a client using a join command.

17 FIG. 3B illustrates a video distribution architecture that includes an
18 exemplary channel change server that is capable of synchronizing a joining to a
19 multicast group for a client using a join command and that is capable of providing
20 a smoother initial video presentation experience.

21 FIG. 4A illustrates a first exemplary mechanism for implementing a join
22 command.

23 FIG. 4B illustrates a second exemplary mechanism for implementing a join
24 command.

1 FIG. 5 is a flow diagram that illustrates an exemplary method for fast
2 channel changing with a combination multicast and unicast network.

3
4 **DETAILED DESCRIPTION**

5 FIG. 1 illustrates an exemplary video distribution architecture 100 that
6 includes a network 104 that is capable of both multicast and unicast
7 communications. Network 104 is implemented with multiple network elements
8 (not separately shown in FIG. 1). Each network element may be capable of
9 facilitating both multicast and unicast communications, or each network element
10 may be capable of facilitating either multicast or unicast communications.
11 Furthermore, network 104 may include some network elements that participate in
12 both multicast and unicast communications and other network elements that
13 participate in either multicast or unicast communications (but not necessarily
14 both).

15 As illustrated, a video provider 102, a channel change server 108, and one
16 or more clients 106(1), 106(2) ... 106(n) are coupled to network 104. Video
17 provider 102 is capable of providing video for multiple channels to clients 106
18 utilizing a multicast scheme over network 104. Likewise, clients 106 are capable
19 of receiving video for multiple channels from video provider 102 via a multicast
20 scheme over network 104. Video as used herein may optionally include audio
21 and/or associated audio/video presentation control information.

22 In a described implementation, video provider 102 receives, stores, and/or
23 otherwise has access to video information for multiple channels as represented by
24 the illustrated video stream 110 for a given particular channel. Each video stream
25 110 is comprised of independent frames 110(I) and dependent frames 110(D).

1 Independent frames 110(I) may be decoded without reference to other video
2 frames. Independent frames 110(I) include, for example, intra (I) frames. In
3 contradistinction, dependent frames 110(D) are decoded with reference to one or
4 more other video frames. Dependent frames 110(D) include, for example,
5 predicted (P) frames and bidirectional (B) frames. Consequently, because
6 independent frames 110(I) may be decoded without waiting for any subsequent
7 frames, independent frames 110(I) may be decoded more quickly and/or sooner
8 than dependent frames 110(D), at least for a video stream 110 that is being
9 received in real-time.

10 Generally, video stream 110 is distributed from video provider 102 over
11 network 104 to selected clients 106 using a multicast scheme. For example, video
12 provider 102 may correspond to a multicast source, network 104 may include
13 multiple multicast replication points, and clients 106 may correspond to multiple
14 multicast receivers. Furthermore, each video stream 110 for a particular video
15 channel may correspond to a multicast stream in a multicast video distribution
16 scheme.

17 In operation, each given client 106 that requests to receive a particular
18 video channel is joined to a multicast group corresponding to that particular video
19 channel. Thereafter, network 104 forwards a duplicate of the associated video
20 stream 110 for the particular video channel that corresponds to the multicast group
21 to which the given client 106 has been joined. Network 104 forwards duplicates
22 of video stream 110 to selected clients 106 via one or more replication points (not
23 separately shown in FIG. 1).

24 When a given client 106 (e.g., client 106(1)) wishes to change channels,
25 client 106(1) transmits a channel change request (CCR) 112 toward a video

1 distribution headend or similar server or system. Channel change request 112
2 includes, in addition to an identifier of client 106(1), an indication of the requested
3 video channel. As illustrated, video provider 102 and channel change server 108
4 separately or jointly comprise a video distribution headend. Channel change
5 request 112 precipitates a multicast group change to a multicast group
6 corresponding to the requested video channel.

7 After the multicast group change, video stream 110 can then be directed to
8 the requesting client 106(1). However, a long channel changing latency may be
9 experienced by the user of client 106(1) if client 106(1) begins receiving video
10 stream 110 during a time period of dependent frames 110(D), which cannot be
11 independently decoded. Client 106(1) waits to decode video until a next
12 independent frame 110(I) is received by client 106(1).

13 In a described implementation, channel change server 108 responds to
14 channel change request 112 to ameliorate this channel changing latency.
15 Specifically, channel change server 108 is adapted to unicast an independent frame
16 110(I) for the requested video channel to client 106(1). More specifically, channel
17 change server 108 is adapted to transmit a retained independent frame 110(I) for
18 the video stream 110 that is associated with the requested video channel to client
19 106(1) in a unicast communication. This retained independent frame 110(I) may
20 then be decoded (and displayed) relatively quickly without regard to other frames
21 110(I or D) and without having to wait for the next independent frame 110(I).

22 Channel change server 108 may operate in any one or more of three
23 exemplary modes when unicasting a retained independent frame. In a first mode,
24 a retained independent frame comprises a cached previous independent frame.
25 This first mode is described further below with reference to FIG. 2. In a second

1 mode, a retained independent frame comprises a cached previous (or possibly
2 buffered) independent frame. This second mode is described further below with
3 reference to FIG. 3A. In a third mode, a retained independent frame comprises a
4 buffered independent frame. This third mode is described further below with
5 reference to FIG. 3B. The second and third modes are implementations that can
6 also involve synchronized joining of clients to a relevant multicast group.

7 FIG. 2 illustrates a video distribution architecture 200 that includes an
8 exemplary channel change server 108 that is capable of providing an intra frame in
9 a unicast message 208. With respect to video distribution architecture 100 (of FIG.
10 1), video provider 102, channel change server 108, and clients 106(1, 2 ... n)
11 remain connected to network 104. However, additional details regarding network
12 104 are provided.

13 As illustrated, network 104 includes at least one replication point 202.
14 Network 104 usually includes many such replication points 202. In fact, multiple
15 replication points 202 are typically located between a multicast source (e.g., video
16 provider 102 and/or channel change server 108) and a multicast receiver (e.g., any
17 client of clients 106). In other words, although only one replication point 202 is
18 explicitly shown, video stream 110 may be communicated (e.g., forwarded and/or
19 duplicated) by multiple replication points 202 between video provider 102 and
20 clients 106.

21 In a described implementation, replication points 202 are realized as any of
22 many different types of network elements or nodes. For example, replication
23 points 202 may be routers, switches, and so forth. As multicast-capable nodes,
24 replication points 202 are adapted to facilitate group membership, to
25 duplicate/forward multicast communications, to handle multicast streams as

1 identified by source and group address (S,G), to perform other multicast-related
2 functions, some combination or subset thereof, and so forth. For example,
3 replication points 202 may be capable of implementing communications in
4 accordance with a multicast routing protocol (e.g., protocol independent multicast
5 – sparse mode (PIM-SM)), in accordance with a group management protocol (e.g.,
6 internet group management protocol (IGMP)), and so forth.

7 IGMP is used by receiver hosts (e.g., at least clients 106) and replication
8 points 202 to notify each other about conditions and changes to group
9 membership. PIM-SM is used to propagate forwarding state information between
10 and among replication points 202. IGMP defines messages that are used to join
11 clients 106 to a group and to notify replication points 202 that a client 106 is
12 leaving a group. Although an implementation is described primarily in the context
13 of IGMP, other multicast protocols may alternatively be employed.

14 Video stream 110 is illustrated as an exemplary stream of I, P, and B
15 frames. Video stream 110 may be coded using any video compression algorithm
16 or technology, such as the Moving Pictures Expert Group 4th standard (MPEG-4:
17 ISO/IEC 14496-1/2/3). The video frame series shown in FIG. 2 is
18 “IBBPBBPBBPBBBI”; however, any video frame series may be present. In fact,
19 the frame series for video stream 110 may be changing in an unknown and/or
20 unpredictable fashion.

21 Channel change server 108 includes one or more processors 206 and at
22 least one memory 204. Memory 204 includes processor-executable instructions
23 that may be executed by processor 206 to perform function(s) as described further
24 below. These processor-executable instructions may comprise hardware,
25 firmware, software, some combination thereof, and so forth. Modules having

1 processor-executable instructions that are stored as part of memory 204 include: I
2 frame cacher 214, cached I frames 216, channel change request detector 218, and
3 channel change request handler 220. These modules are described further herein
4 below.

5 As noted generally above with reference to video stream 110, I frames can
6 be independently decoded, but P and B frames usually cannot. P frames reference
7 up to one other frame, and B frames reference up to two other frames. When a
8 particular client 106 joins a new multicast group corresponding to a different video
9 channel, the particular client 106 is unable to begin decoding video stream 110 (or
10 display any video for the user) until an I frame is received. Under an MPEG-4
11 video coding paradigm, the average delay between a channel change request 112
12 and receipt of an I frame during normal stream flow can be 1-2 seconds. This
13 delay can lengthen to 5-10 seconds with next generation coding paradigms.
14 Channel change server 108 can reduce this average delay and thereby ameliorate
15 user frustrations arising from long channel changing delays.

16 In a described implementation, client 106(1) initially determines that a
17 video channel change is desired (e.g., as a result of user input) and/or being
18 demanded. Client 106(1) formulates a channel change request 112 that indicates a
19 requested channel and identifies (perhaps implicitly) client 106(1). Channel
20 change request 112 is transmitted upstream (e.g., as a unicast message) through
21 one or more replication points 202.

22 Channel change request detector 218 configures channel change server 108
23 to be monitoring network 104 for channel change requests 112. When channel
24 change request 112 from client 106(1) is detected, channel change request handler
25 220 is activated to respond to it. Specifically, channel change request handler 220

1 responds by sending a previous I frame for the requested channel to client 106(1)
2 in a unicast message.

3 In order to be able to send previous I frames for requested channels to
4 clients 106, channel change server 108 secures access to such previous I frames by
5 retaining them at least temporarily. Specifically, I frame cacher 214 tracks each
6 video stream 110 that is associated with each video channel and stores at least the
7 immediately most recent previous I frame for each video stream 110. These most
8 recent previous I frames are stored as cached I frames 216.

9 As illustrated in FIG. 2, the activation time of channel change request 112 is
10 indicated along video stream 110 as time of CCR 212. This time of CCR 212 falls
11 between two I frames. Hence, retained I frame 210, which comprises a cached or
12 previous I frame in this mode, has already been stored at cached I frames 216 by I
13 frame cacher 214. Channel change request handler 220 extracts retained I frame
14 210 from cached I frames 216. Channel change request handler 220 also
15 formulates a unicast message (UM) that includes retained I frame 210 and
16 transmits it as retained I frame UM 208 toward client 106(1).

17 Client 106(1) receives retained I frame UM 208 and can decode and display
18 retained I frame 210 thereof while awaiting the next I frame of video stream 110
19 that is associated with the requested channel. The faster that retained I frame UM
20 208 is received by client 106(1), the shorter the delay between when a user
21 requests a channel change and when a full (initially static) video frame is
22 displayed and the less likely that transmission of retained I frame 210 in retained I
23 frame UM 208 is to interfere with the reception of current and possibly more-
24 relevant (e.g., newer) frames of video stream 110. Hence, transmission bandwidth
25 at least between client 106(1) and the replication point 202 that is most proximate

1 thereto can be an issue. Addressing this transmission bandwidth issue is described
2 below with reference to FIGS. 3A and 3B.

3 FIG. 3A illustrates a video distribution architecture 300A that includes an
4 exemplary channel change server 108 that is capable of synchronizing a joining to
5 a multicast group for client 106(1) using a join command. With respect to video
6 distribution architecture 200 (of FIG. 2), video provider 102, channel change
7 server 108, and clients 106(1, 2 ... n) remain connected to network 104. However,
8 video provider 102 provides video streams 110 via channel change server 108.
9 Although shown separately, video provider 102 and channel change server 108
10 (e.g., in FIGS. 1-3B) may be co-located and/or combined into a single server or
11 system.

12 In a described implementation, channel change server 108 is adapted to
13 buffer video stream 110 to delay it in time before multicast streaming distribution
14 thereof. Channel change server 108 is capable of synchronizing a joining to a new
15 channel to just prior to a new I frame for a video stream 110 that is associated with
16 the new channel by "predicting" the occurrence of a next I frame. This quasi-
17 prediction is accomplished using the time delay aspect of the buffered portion of
18 video stream 110.

19 As illustrated, channel change server 108 includes memory 204 that has
20 processor-executable instructions, which may be executed by processor 206 to
21 perform function(s) as described further below. Modules having processor-
22 executable instructions that are stored as part of memory 204 include: video
23 stream bufferer 304, buffered video stream 306, join command issuer 308, and
24 synchronization determiner 310. The functions of modules 304, 306, 308, and 310
25

1 may be implemented in conjunction with or separately from those of modules 214,
2 216, 218, and 220 (of FIG. 2).

3 Channel change server 108 accepts video stream 110 (for each video
4 channel) from video provider 102. Video stream bufferer 304 creates a buffered
5 portion 312(T) of video stream 110 between a receive point (RP) and a send point
6 (SP). Each currently-buffered buffered portion 312 is stored as buffered video
7 stream 306. Buffered portion 312(T) corresponds to a current time "T". The
8 receive point corresponds to the point along video stream 110 at which channel
9 change server 108 is currently receiving from video provider 102. The send point
10 corresponds to the point along video stream 110 at which channel change server
11 108 is currently sending toward clients 106.

12 In a described implementation, client 106(1) transmits upstream (e.g., as a
13 unicast message) channel change request 112, possibly through one or more
14 replication points 202 depending on the upstream path. The activation time of
15 CCR 212 is indicated with respect to video stream 110 and buffered portion
16 312(T). Retained I frame 210 may be sent in retained I frame UM 208 by channel
17 change request handler 220 (as described above with reference to FIG. 2). In this
18 mode, retained I frame 210 comprises a cached or buffered I frame. If the retained
19 I frame 210 happens to be within buffered portion 312(T), it may be retrieved
20 directly from buffered video stream 306, possibly even prior to being cached as
21 part of cached I frames 216 if I frames are not cached until they are sent at the
22 send point SP.

23 Because full decoding of true motion video does not start until reception of
24 the next upcoming I frame, transmission of intervening P and/or B frames can be
25 considered unnecessary bandwidth usage. To avoid such bandwidth squandering

1 and to increase the likely speed at which retained I frame UM 208 is received by
2 client 106(1), synchronization determiner 310 is capable of causing client 106(1)
3 to be joined to the multicast group corresponding to the requested channel just in
4 time to receive the next decodable frame. This may, for example, amount to as
5 little "excess bandwidth" utilization as a few packets before the next I frame to as
6 much "excess bandwidth" as multiple frames. In this mode, the next decodable
7 frame comprises another I frame.

8 Specifically, synchronization determiner 310 ascertains whether the next I
9 frame is present within the current buffered portion 312 of video stream 110. At
10 time of CCR 212, the next decodable frame 314 is not within buffered portion
11 312(T). However, after "X" unit(s) of time, the next decodable frame 314 is
12 within buffered portion 312(T+X). When synchronization determiner 310
13 ascertains that the next decodable frame 314 is within the current buffered portion
14 312, synchronization determiner 310 determines that it is time to issue a join
15 command and thus activates or prompts join command issuer 308.

16 Join command issuer 308, once activated, issues a join command over
17 network 104 (not explicitly indicated in FIG. 3A for clarity). The join command
18 causes a join message 302 to be received at replication point 202. Join message
19 302 notifies replication point 202 that client 106(1) is to begin receiving the
20 multicast stream that corresponds to the requested channel by joining client 106(1)
21 to the multicast group for that multicast stream. This join message 302 may be
22 transmitted from client 106(1) or join command issuer 308 of channel change
23 server 108. The former is described further below with reference to FIG. 4A, and
24 the latter is described further below with reference to FIG. 4B. In the latter
25

1 implementation, the join command that is issued by join command issuer 308 may
2 comprise join message 302.

3 In a described implementation, the size of buffered portion 312 relates to an
4 expected (including a known) time that is consumed when joining a client 106 to a
5 multicast group of a multicast channel. This time may include a time period to
6 effectuate a leave operation. By way of example, buffered portion 312 may
7 correspond to a worst case (e.g., absolute or reasonable worst case) scenario for
8 effectuating a join operation for any of the relevant clients 106. Alternatively, the
9 size of buffered portion 312 may correspond to an average time to effectuate a
10 multicast join operation, may be tailored for each individual or designated set of
11 clients 106 if conditions of network 104 vary spatially or temporally, and so forth.

12 FIG. 3B illustrates a video distribution architecture 300B that includes an
13 exemplary channel change server 108 that is capable of synchronizing a joining to
14 a multicast group for client 106(1) using a join command and that is capable of
15 providing a smoother initial video presentation experience. Video distribution
16 architecture 300A can result in a video gap or discontinuity that is experienced by
17 a user of a client 106. This video gap/discontinuity results from the consecutive
18 display of two non-consecutive I frames, which have multiple intervening un-
19 displayed non-I frames. Video distribution architecture 300B ameliorates this
20 video gap/discontinuity by smoothing the video presentation as described below.

21 For the sake of clarity, video stream bufferer 304, join command issuer 308,
22 and synchronization determiner 310 are not shown in FIG. 3B. However, a longer
23 segment of video stream 110 is illustrated. Buffered portion 312(T*) is longer
24 than buffered portion 312(T) (of FIG. 3A). Buffered portion 312(T*) includes a
25 joining time 316 and an I frame interval duration 318, as described below.

1 In a described implementation for this third mode, channel change server
2 108 is adapted to buffer video stream 110 to delay it in time, before multicast
3 streaming distribution thereof, by at least the maximum distance between I frames
4 plus the maximum join-time for client 106(1) to become joined to the multicast
5 group corresponding to the requested channel. Channel change server 108 is
6 capable of synchronizing a joining to a new channel to just after a new I frame for
7 a video stream 110 that is associated with the new channel by "predicting" the
8 occurrences of I frames. This quasi-prediction is accomplished using the time
9 delay aspect of the buffered portion 312(T*) (e.g., the delay window) of video
10 stream 110.

11 Channel change server 108 is adapted to retain I frames within buffered
12 portion 312(T*). The retained I frames may be retained by I frame cacher 214 as
13 cached I frames 216 or as recorded pointers/indexes to I frames that are in the
14 buffered window. Alternatively, the retained I frames may be retained within
15 buffered portion 312(T*) without using an I frame cacher 214. In a described
16 implementation for this mode, retained I frame 210 comprises a buffered I frame.

17 When client 106(1) requests a channel change via a CCR 112, channel
18 change server 108 provides the oldest retained I frame 210 within the delay
19 window of buffered portion 312(T*) for which client 106(1) still has time to
20 receive a retained I frame UM 208 and to join the multicast group in time to
21 receive the frame immediately subsequent to the oldest retained I frame 210. In
22 this manner, client 106(1) receives a contiguous set of frames, with the first frame
23 being a retained I frame 210 arriving via a retained I frame UM 208 and the
24 (initial) subsequent frames being non-I frames arriving via the multicast group.
25 Client 106(1) pauses on the retained I frame 210 because it is sent "ahead of time",

1 and client 106(1) then begins full motion video when it is time to play the
2 immediately subsequent frame that is obtained from the delayed multicast stream.

3 Joining time 316 corresponds to the time consumed when joining a client
4 106 to a multicast group, as described above with reference to FIG. 3A. I frame
5 interval duration 318 corresponds to the greatest possible time period between
6 successive I frames for the given coding scheme. As illustrated, a first time of
7 CCR 212' is shown arriving just as joining time 316 is about to start.
8 Consequently, a first retained I frame 210', which is a buffered I frame in this
9 implementation of the third mode, and a first next decodable frame 314' are the
10 first two frames that a client 106 receives to start video decoding. A second time
11 of CCR 212'' is shown arriving after expiration of joining time 316 with respect to
12 retained I frame 210' but prior to expiration of a joining time 316 (not explicitly
13 shown) with respect to retained I frame 210''. Consequently, a second retained I
14 frame 210'', and a second next decodable frame 314'' are the first two frames that
15 a client 106 receives to start video decoding for second time of CCR 212''.

16 FIG. 4A illustrates a first exemplary mechanism 308*A for implementing a
17 join command. Exemplary mechanism 308*A involves participation by client 106
18 as well as channel change server 108 and replication point 202. Specifically,
19 channel change server 108 transmits a join instruction UM 402 to client 106 via
20 replication point 202. Join instruction UM 402 stipulates to client 106 when to
21 transmit its join message responsive to the determination made by synchronization
22 determiner 310 (of FIGS. 3A and 3B) of channel change server 108. At the
23 appointed stipulated time, client 106 transmits join message 302A to replication
24 point 202 so that client 106 is joined to the multicast group corresponding to the
25 requested channel in time to receive the next decodable frame 314 and without

1 receiving a significant amount of earlier non-I (or inter) frame(s) or otherwise non-
2 decodable frame(s).

3 This joining delay of the multicast stream facilitates bandwidth availability
4 for the unicast delivery of retained I frame 210 (of FIGS. 2, 3A, and 3B).
5 Replication point 202 may be, for example, the replication point 202 that is closest
6 to client 106 and capable of multicasting the desired video stream 110.

7 To the extent that the join operation is precipitated by a join message 302A
8 that is transmitted from client 106, exemplary mechanism 308*A comports with a
9 more-typical multicast joining procedure. However, the logistics involved are
10 non-trivial inasmuch as three network elements are involved in the instigation of
11 the join message and because setting time constraints (e.g., as reflected by the size
12 of buffered portion 312) becomes concomitantly more difficult and/or more
13 extreme for worst case analysis. The joining procedure can be simpler and more
14 certain if client 106 is not obligated to participate.

15 FIG. 4B illustrates a second exemplary mechanism 308*B for implementing
16 a join command. Exemplary mechanism 308*B involves participation by channel
17 change server 108 and replication point 202. Specifically, channel change server
18 108 transmits a join message 302B to replication point 202. Join message 302B is
19 transmitted responsive to the determination made by synchronization determiner
20 310 and likely involves less lead time for effectuating the joining operation with
21 sufficient clearance to receive the next decodable frame 314. Join message 302B
22 notifies replication point 202 that client 106 is to be joined to the multicast group
23 corresponding to the requested channel. Exemplary mechanism 308*B entails
24 enabling non-receiver hosts, such as sender/source hosts, to be capable of
25 precipitating join operations on behalf of receiver hosts.

1 FIG. 5 is a flow diagram 500 that illustrates an exemplary method for fast
2 channel changing with a combination multicast and unicast network. Flow
3 diagram 500 includes thirteen (13) blocks 502-526. Although the actions of flow
4 diagram 500 may be performed in other environments and with a variety of e.g.
5 software schemes, FIGS. 2, 3A-3B, and 4A-4B are used in particular to illustrate
6 certain aspects and examples of the method.

7 For example, the actions of blocks 502-526 may be performed by a channel
8 change server 108 and a client 106, possibly in conjunction with one or more
9 replication points 202 of a network 104. As illustrated, channel change server 108
10 performs the actions of blocks 502-516, and client 106 performs the actions of
11 blocks 518-526.

12 At block 502, a video stream is accepted. For example, channel change
13 server 108 may accept one or more video streams 110 from an associated video
14 provider 102. At block 504, a portion of the accepted video stream is buffered.
15 For example, video stream bufferer 304 may delay each video stream 110 that is
16 associated with each channel to create buffered portion 312 for each video stream
17 110. The buffered portions 312 may be stored as a set of buffered video streams
18 306 with frames that enter at the receiving point (RP) and "move" toward the
19 sending point (SP).

20 At block 506, at least one I frame is retained. For example, I frame cacher
21 214 of channel change server 108 may retain the retained frame (e.g., retained I
22 frame 210) of each video stream 110 that is associated with each channel as a set
23 of cached I frames 216 or a set of indexes/pointers to frames in a buffered portion
24 312(T*). Alternatively, I frames may be retained by being buffered at known or
25 determinable locations of buffered portion 312(T*). As indicated by the dashed

1 arrow that diverges from point 528, the actions of blocks 502-506 are ongoing for
2 channel change server 108.

3 At block 518, video is being received via multicast communication. For
4 example, client 106 may be receiving video stream 110 from video provider 102
5 and/or channel change server 108 as a multicast stream over one or more
6 replication points 202 of network 104. At block 520, a channel change request is
7 transmitted as a unicast message. For example, client 106 may transmit a channel
8 change request 112 as a unicast message toward channel change server 108. This
9 channel change request 112 is effectively a request to switch from a first multicast
10 group corresponding to a first video channel to a second multicast group
11 corresponding to a second video channel, with the requested second video channel
12 being indicated by channel change request 112.

13 At block 508, a channel change request is detected. For example, channel
14 change request detector 218 of channel change server 108 may detect channel
15 change request 112. If video distribution architecture 200 is implemented, channel
16 change server 108 may be monitoring links of and/or interfaces to network 104 in
17 the vicinity of video provider 102 for channel change requests 112, or video
18 provider 102 may be forwarding channel change requests 112 (or channel change
19 server 108 may be the intended recipient of channel change requests 112). If
20 video distribution architecture 300A or 300B is implemented, channel change
21 server 108 may be the intended recipient of channel change requests 112, and so
22 forth.

23 At block 510, a retained I frame for the requested channel is retrieved. For
24 example, channel change request handler 220 accesses cached I frames 216 and/or
25 buffered portion 312(T*) of buffered video stream 306 to retrieve the retained I

1 frame (e.g., retained I frame 210, including 210' and 210'') for the video stream
2 110 associated with the requested channel. At block 512, the retained I frame for
3 the requested channel is transmitted as a unicast message. For example, channel
4 change request handler 220, after appropriate formulation, transmits retained I
5 frame UM 208 toward client 106.

6 At block 522, the retained I frame for the requested channel is received as a
7 unicast message. For example, client 106 may receive retained I frame UM 208,
8 which is an example of a unicast communication, even though client 106 usually
9 receives video streams 110 as multicast streams during standard video channel
10 reception. At block 524, the retained I frame for the requested channel is
11 displayed. For example, client 106 extracts the retained I frame for the requested
12 channel from the retained I frame UM 208 and causes the retained I frame to be
13 displayed. Depending on the time period until the next decodable frame 314
14 (including 314' and 314'') is due, this static I frame presentation may continue for
15 a noticeable time (e.g., up to 1-2 seconds in a typical MPEG-4 video coding
16 implementation).

17 At block 514, the client's joining to the multicast group that corresponds to
18 the requested channel is synchronized with regard to the next decodable frame.
19 For example, for video distribution architectures 300A and 300B, synchronization
20 determiner 310 of channel change server 108 may ascertain when the next
21 decodable frame 314 is due to be sent to (and thereby when next decodable frame
22 314 is likely to be received or will be received in a worst-case scenario by) client
23 106. This next decodable frame 314 ascertainment may be performed with
24 reference to buffered portion 312 (including buffered portion 312(T*) and joining
25 time 316 thereof) for the video stream 110 that is associated with the requested

1 channel. Once the timing of next decodable frame 314 is ascertained,
2 synchronization determiner 310 determines the appropriate timing for the
3 multicast joining operation of client 106 to the multicast group corresponding to
4 the requested channel.

5 At block 516, a join command is issued for the requesting client. For
6 example, join command issuer 308 may issue a join command with respect to
7 client 106 responsive to a synchronization determination by synchronization
8 determiner 310. The join command may comprise a join instruction unicast
9 message 402 that is sent to client 106 to prompt client 106 to transmit a join
10 message 302A at an appointed time to a replication point 202 (e.g., exemplary
11 mechanism 308*A for implementing a join command). Alternatively, the join
12 command may comprise a join message 302B that is sent "directly" to a
13 replication point 202 on behalf of client 106 (e.g., exemplary mechanism 308*B
14 for implementing a join command).

15 At block 526, video for the requested channel is received via multicast
16 communication. For example, client 106 may receive video stream 110 that is
17 associated with the requested channel via a corresponding multicast streaming
18 group over network 104 using multiple replication points 202. In other words,
19 after a replication point 202 has caused client 106 to be joined to the
20 corresponding multicast streaming group responsive to a join message 302, at least
21 that one replication point 202 duplicates (as necessary) and forwards video stream
22 110 to client 106.

23 The actions of blocks 512 and 516 may, in particular, be performed in a
24 myriad of orders. For example, the issuance of block 516 may occur after the
25 transmission of block 512, or the issuance and transmission of blocks 516 and 512

1 may occur substantially simultaneously or at least without consideration of the
2 order of either. Alternatively, the issuance of block 516 may be performed after
3 the transmission of block 512 unless a next I frame is of such temporal proximity
4 (e.g., closer than a predetermined threshold period) that waiting to issue the join
5 command jeopardizes the ability of a channel changing client to receive the next I
6 frame.

7 The actions, aspects, features, components, etc. of FIGS. 1-5 are illustrated
8 in diagrams that are divided into multiple blocks. However, the order,
9 interconnections, layout, etc. in which FIGS. 1-5 are described and/or shown is not
10 intended to be construed as a limitation, and any number of the blocks can be
11 combined, rearranged, augmented, omitted, etc. in any manner to implement one
12 or more systems, methods, devices, procedures, media, apparatuses, servers,
13 arrangements, etc. for fast channel changing. Furthermore, although the
14 description herein includes references to specific implementations, the illustrated
15 and/or described implementations can be implemented in any suitable hardware,
16 software, firmware, or combination thereof and using any suitable video
17 distribution architecture(s), network element(s) and organization(s), video
18 encoding standard(s), multicast and unicast scheme(s), and so forth.

19 With particular reference to FIGS. 2 and 3A-3B, a video provider 102
20 and/or a server 108 may include a variety of processor-accessible media. Such
21 media may be any available media that is accessible by a computing or other (e.g.,
22 electronic) device. Such media may include both volatile and non-volatile media,
23 removable and non-removable media, and storage (e.g., memory 204) and
24 transmission media (e.g., links or nodes of network 104). The media may include
25 processor-executable instructions.

1 Implementations for fast channel changing may be described in the general
2 context of processor-executable instructions. Generally, processor-executable
3 instructions include routines, programs, protocols, objects, interfaces, components,
4 data structures, etc. that perform and/or enable particular tasks and/or implement
5 particular abstract data types. Fast channel changing, as described in certain
6 implementations herein, may also be practiced in distributed processing
7 environments where tasks are performed by remotely-linked processing devices
8 that are connected through a communications link and/or network. Especially but
9 not exclusively in a distributed computing environment, processor-executable
10 instructions may be located in separate storage media, executed by different
11 processors, and/or propagated over transmission media.

12 Although systems, media, devices, methods, procedures, apparatuses,
13 techniques, schemes, approaches, procedures, arrangements, and other
14 implementations have been described in language specific to structural, logical,
15 algorithmic, and functional features and/or diagrams, it is to be understood that the
16 invention defined in the appended claims is not necessarily limited to the specific
17 features or diagrams described. Rather, the specific features and diagrams are
18 disclosed as exemplary forms of implementing the claimed invention.

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CLAIMS:

1. A method for fast channel changing in a multicast video distribution architecture, the method comprising:

buffering a multicast video stream segment at a server, the buffered
 5 multicast video stream segment including a first retained intra frame and a second retained intra frame, the first retained intra frame being before the second retained intra frame in the buffered multicast video stream segment;

detecting a channel change request that indicates a requested channel, the
 channel change request being from a requesting device, the requested channel
 10 corresponding to the buffered multicast video stream segment;

determining whether a first next decodable non-intra frame after the first
 retained intra frame is at least a joining time after a send point of the buffered multicast
 video stream segment;

in response to detecting the channel change request, transmitting to the
 15 requesting device a retained intra frame and no dependent frames for the requested channel as a unicast communication for static display, wherein,

if the first next decodable non-intra frame after the first retained intra frame
 is determined to be at least the joining time after the send point of the buffered multicast
 video stream segment, then the transmitted retained intra frame is the first retained intra
 20 frame and the first next decodable non-intra frame after the first retained intra frame is a joining frame, and wherein

if the first next decodable non-intra frame after the first retained intra frame
 is determined to be less than the joining time after the send point of the buffered multicast
 video stream segment, then the transmitted retained intra frame is the second retained
 25 intra frame and a second next decodable non-intra frame after the second retained intra frame is the joining frame; and

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synchronizing a multicast joining operation to a multicast group corresponding to the requested channel, wherein synchronizing includes ensuring the joining frame is the oldest non-intra frame of the buffered multicast video stream segment received by the requesting device in response to the channel change request after the
5 multicast joining operation.

2. The method as recited in claim 1, further comprising:

 caching at least one previous intra frame for each channel of a plurality of channels as a set of cached intra frames; and

 retrieving, responsive to the detecting, the retained intra frame for the
10 requested channel from the set of cached intra frames, the retained intra frame comprising a previous intra frame.

3. The method as recited in claim 1, wherein:

 the detecting comprises detecting the channel change request from a particular client; and

 the transmitting comprises transmitting the retained intra frame to the
15 particular client.

4. The method as recited in claim 1, further comprising:

 wherein the joining comprises determining when the retained intra frame reaches a joining time of the buffered video stream portion.

20 5. A method for fast channel changing in a multicast video distribution architecture, the method comprising:

 sending a channel change request to a server, the channel change request indicating a requested channel, the server buffering a multicast video stream segment, the buffered multicast video stream segment including a first retained intra frame and a
25 second retained intra frame, the first retained intra frame being before the second retained

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intra frame in the buffered multicast video stream segment, the requested channel corresponding to a multicast group and the buffered multicast video stream segment corresponding to the requested channel, wherein the server determines whether a first next decodable non-intra frame after the first retained intra frame is at least a joining time
5 after a send point of the buffered multicast video stream segment;

in response to sending the channel change request, receiving a retained intra frame for the requested channel as a unicast communication, wherein

if the first next decodable non-intra frame after the first retained intra frame is determined to be at least the joining time after the send point of the buffered multicast
10 video stream segment, then the transmitted retained intra frame is the first retained intra frame and the first next decodable non-intra frame after the first retained intra frame is a joining frame, and wherein

if the first next decodable non-intra frame after the first retained intra frame is determined to be less than the joining time after the send point of the buffered multicast
15 video stream segment, then the transmitted retained intra frame is the second retained intra frame and a second next decodable non-intra frame after the second retained intra frame is the joining frame;

statically displaying the received retained intra frame;

receiving as a multicast communication a portion of the multicast video
20 stream corresponding to the requested channel, wherein the initial multicast frame of the multicast video stream received is the joining frame, the portion including a plurality of consecutive multicast frames of the multicast video stream; and

switching from statically displaying the received retained intra frame to displaying the portion of the multicast video stream.

25 6. One or more non-transitory processor-readable storage media having processor-executable instructions stored thereon, the instructions, when executed, causing an apparatus to perform the method of any one of claims 1 to 5.

Docket No: MS1-1758US 1 of 6
Inventor(s): Barrett et al.
Title: Fast Channel Change

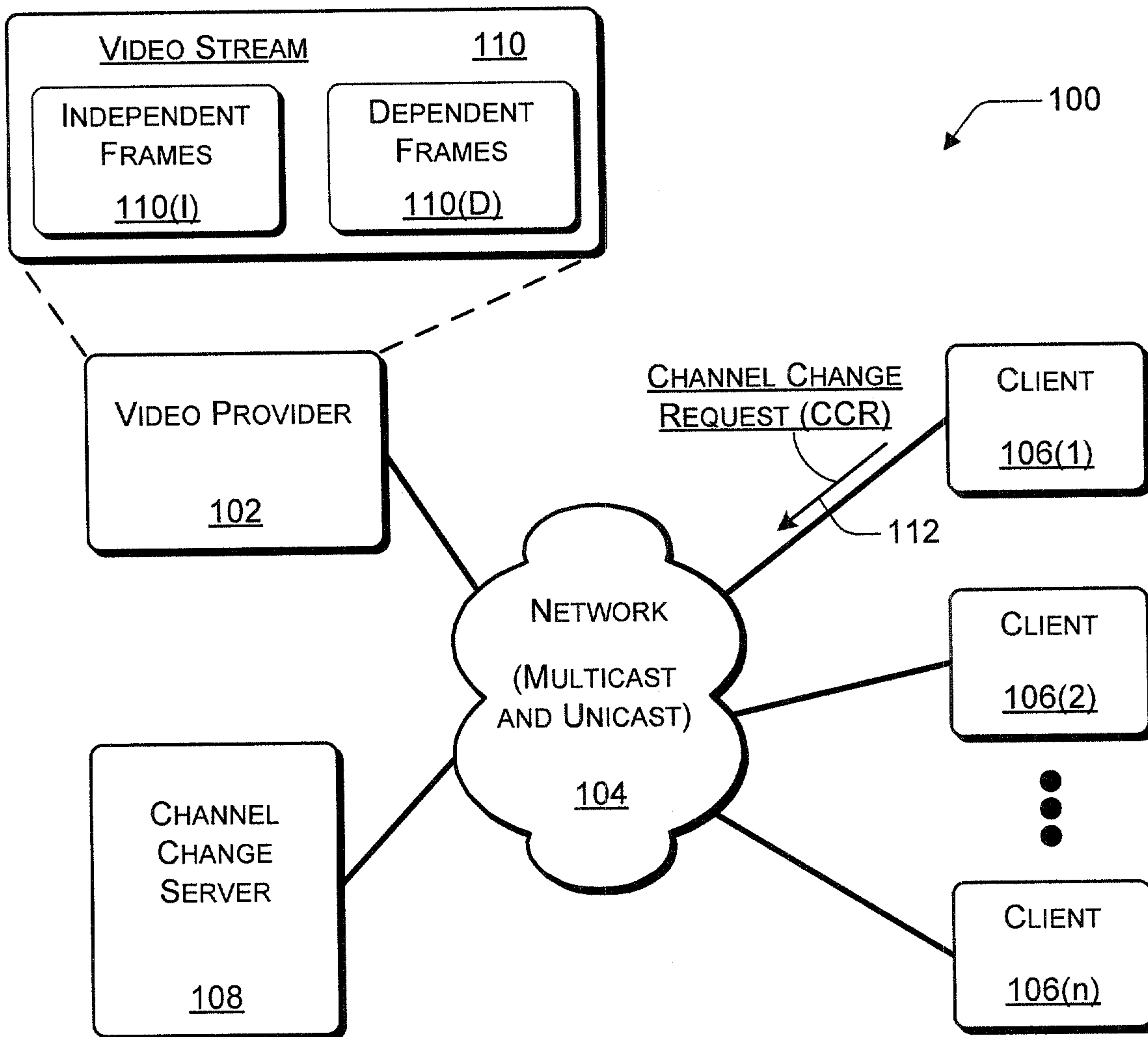


FIG. 1

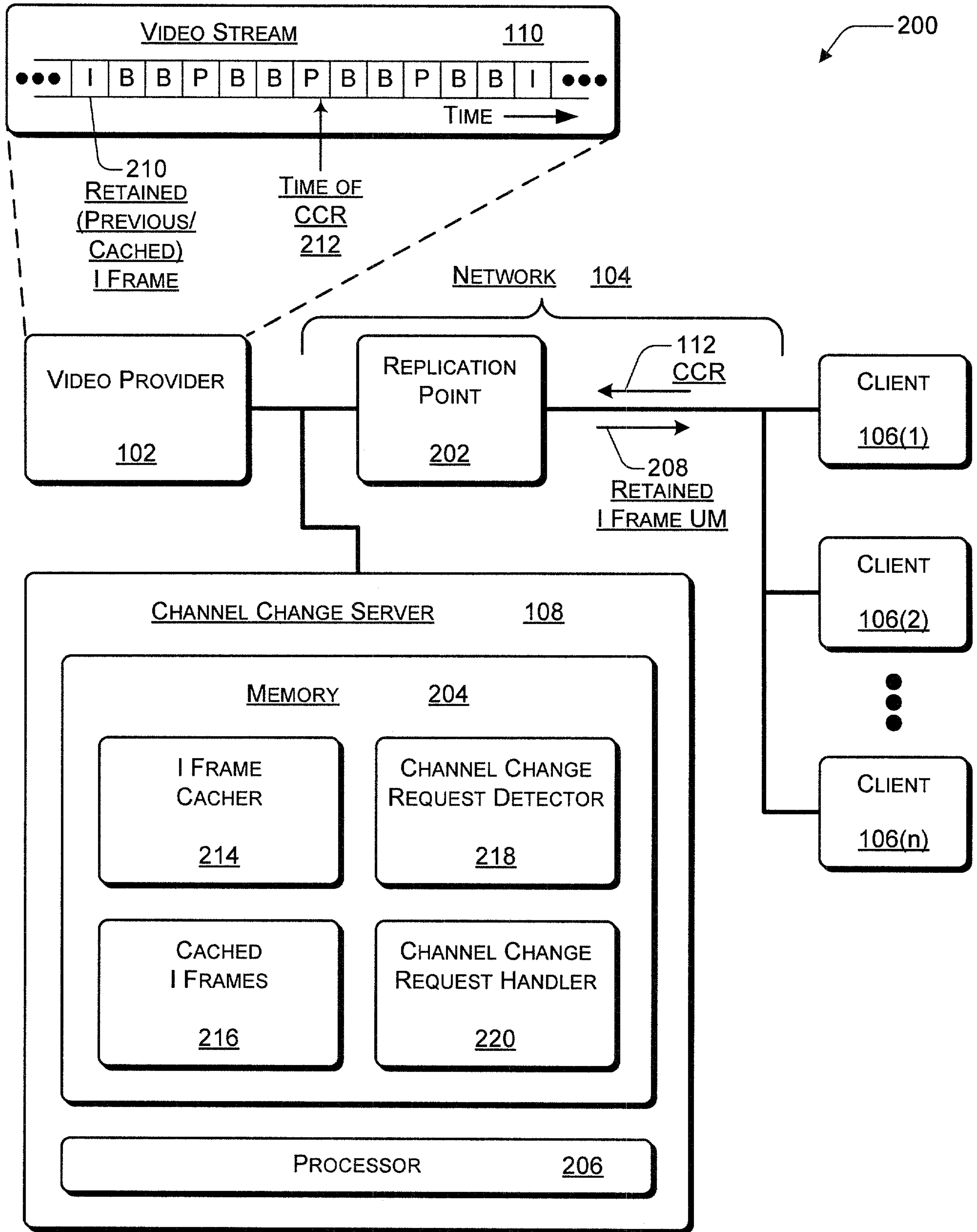


FIG. 2

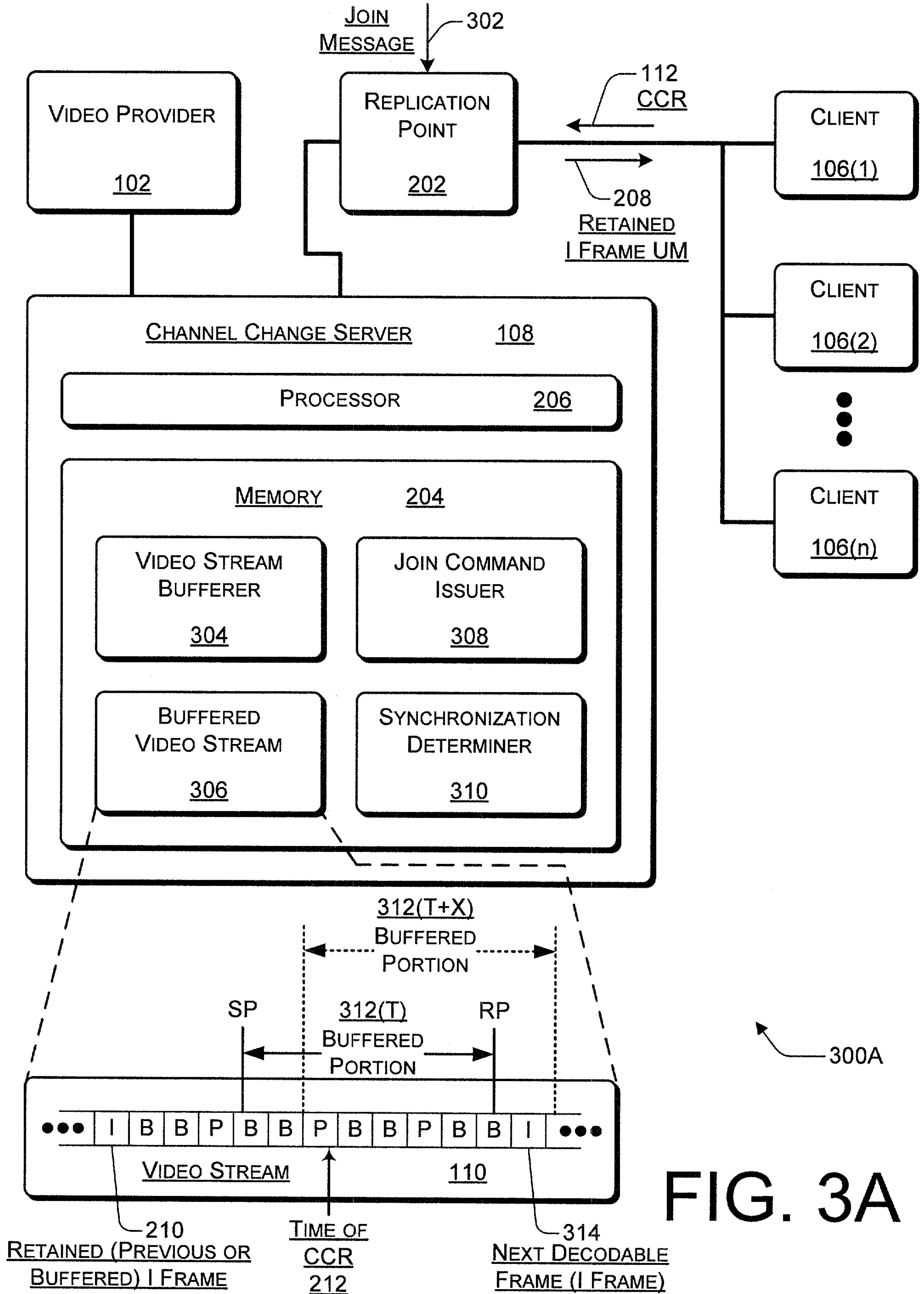


FIG. 3A

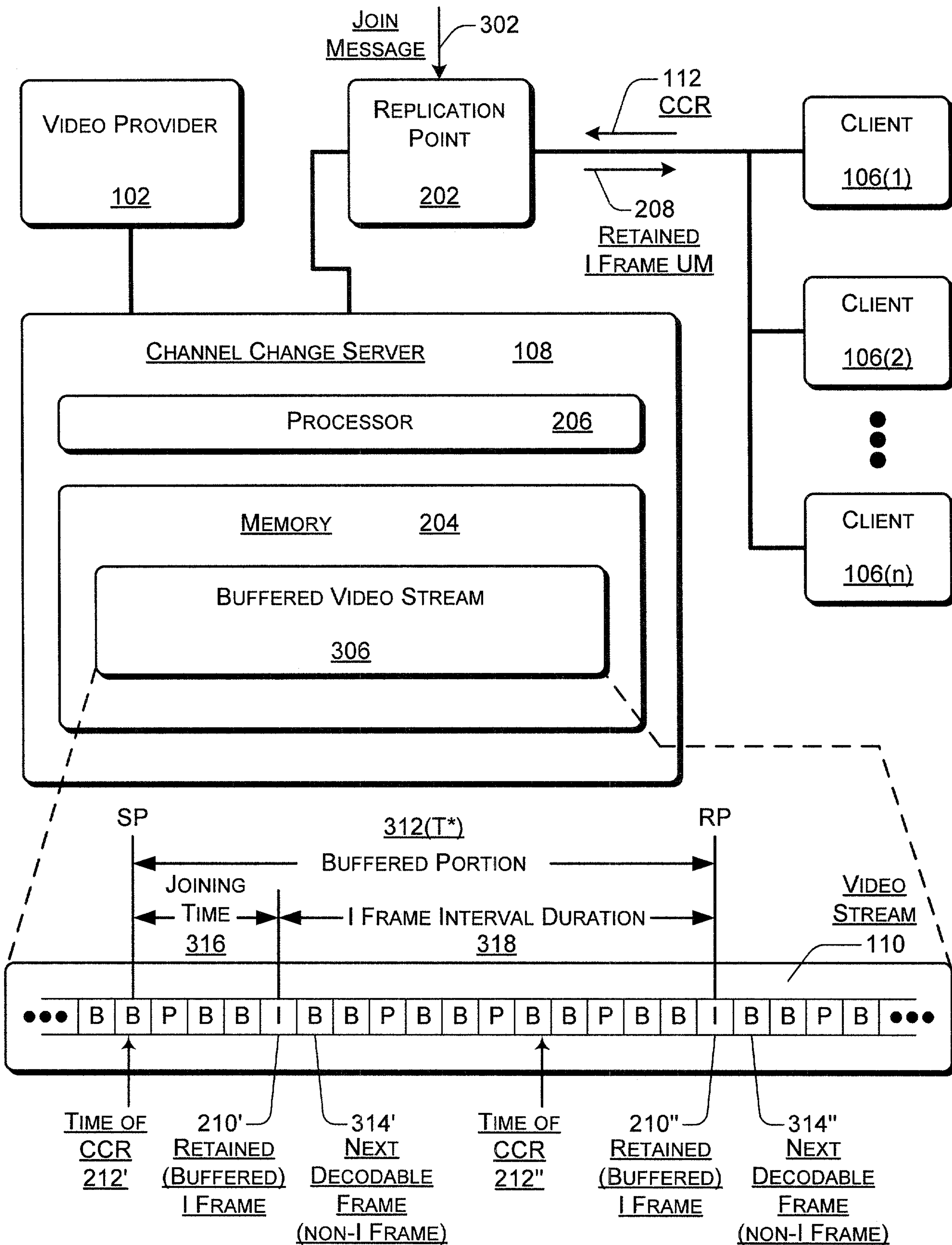


FIG. 3B

300B

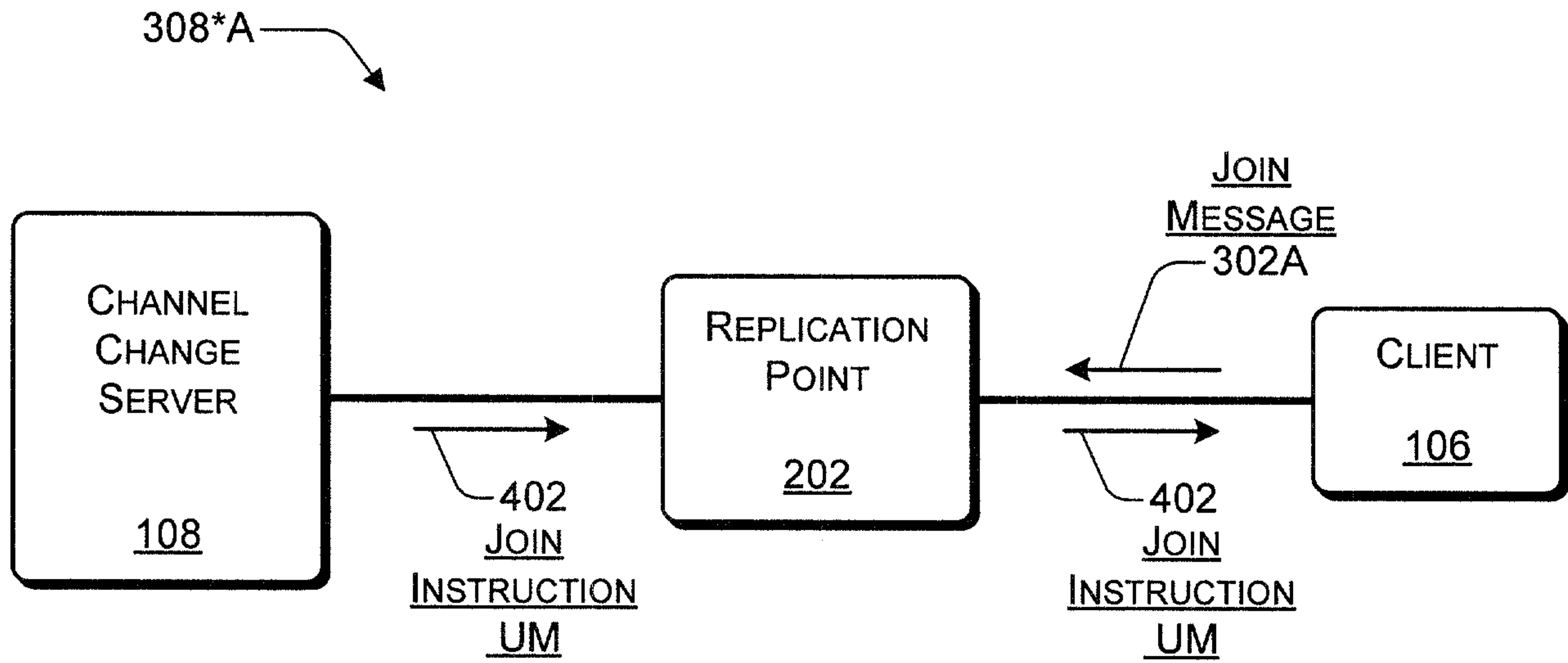


FIG. 4A

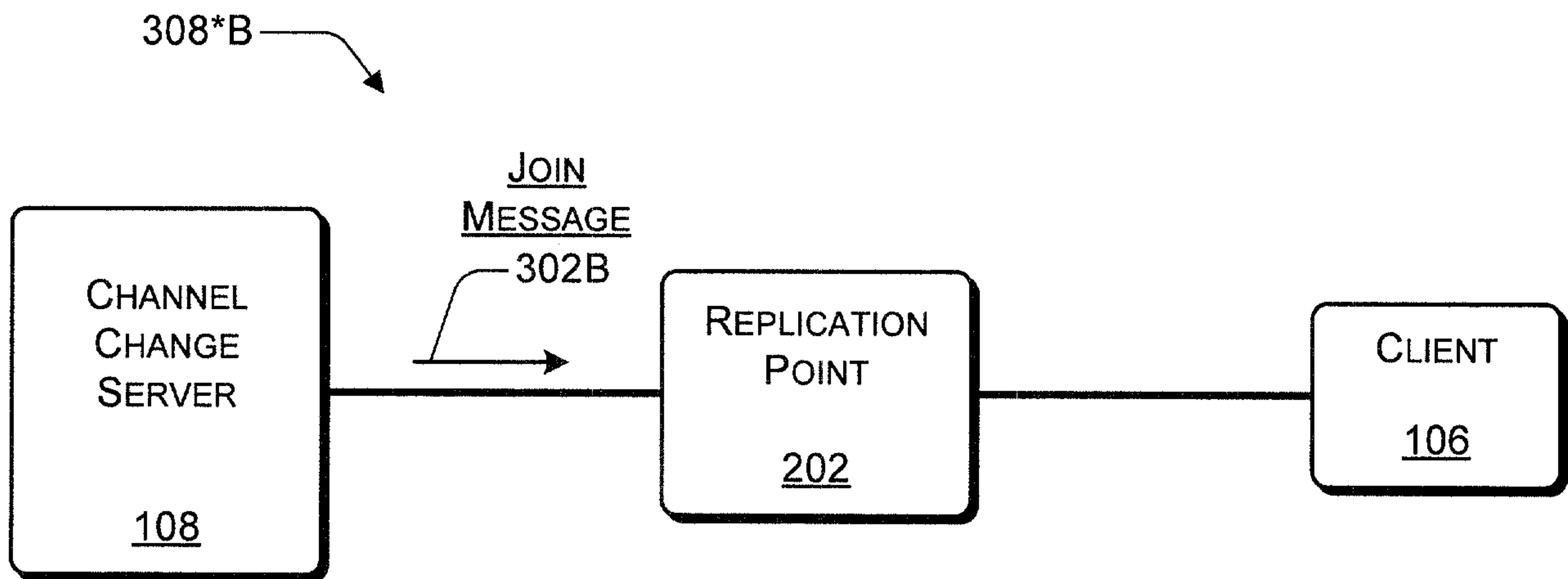


FIG. 4B

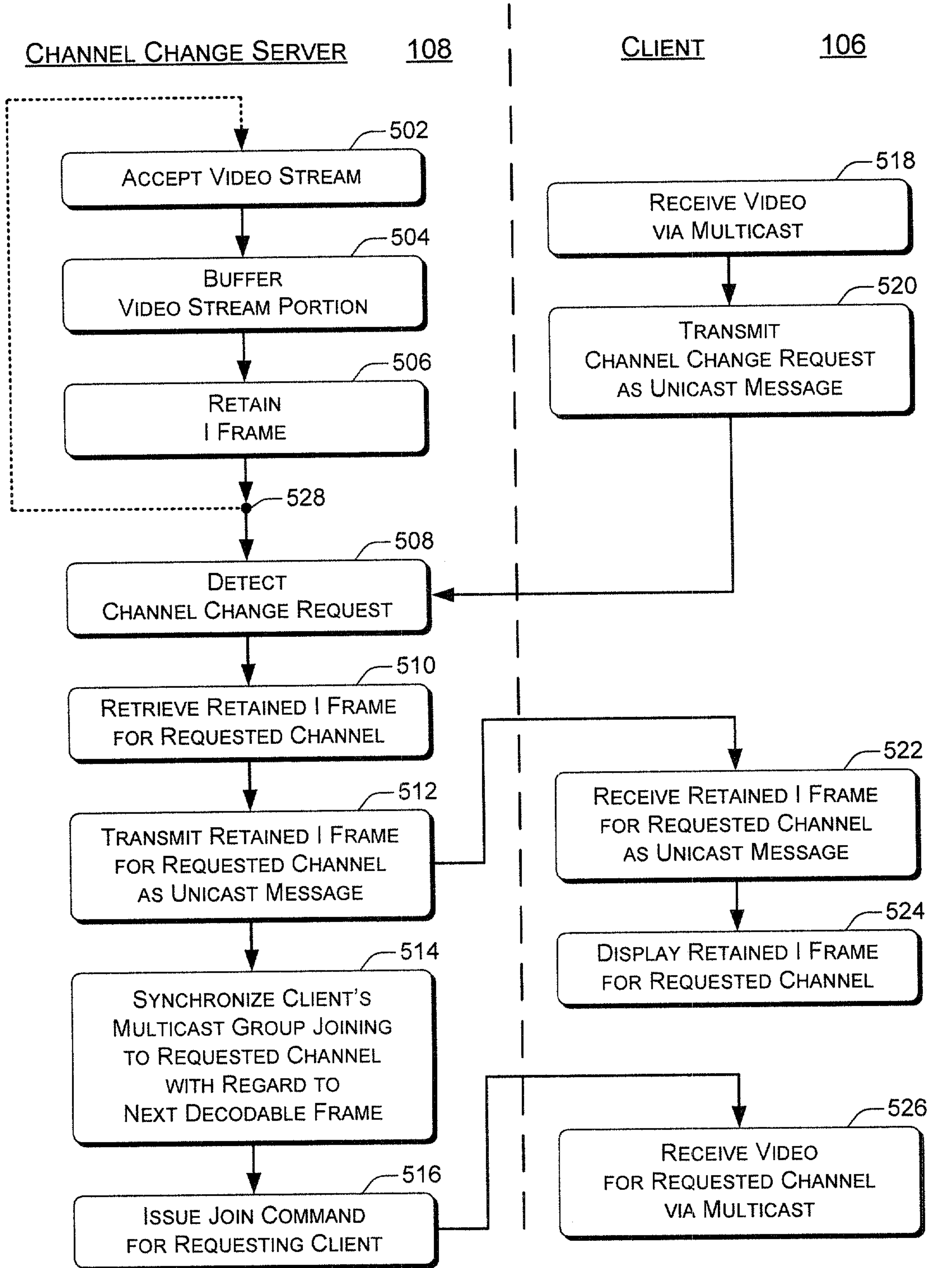


FIG. 5

500

