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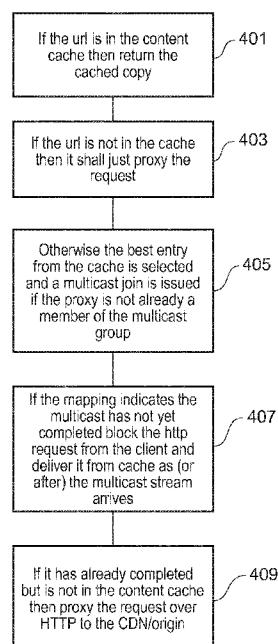


FIG. 4

(57) Abstract: A method is disclosed for providing multicast adaptive bitrate content to user equipment, the method comprising storing data representing a mapping from a content identifier to a multicast address for the content at a proxy configured to distribute the content, the data including a start value associated with delivery of the content or fragments thereof to the proxy, receiving a request for content from user equipment, using the data representing the mapping, determining whether the content is available at the proxy or will become available within a threshold period of time using the start time, and delivering the content to the user equipment from the proxy.



PROVIDING MULTICAST ADAPTIVE BITRATE CONTENT

FIELD OF THE INVENTION

Aspects relate, in general to a method for providing an adaptive content to user
5 equipment.

BACKGROUND

The term unicast relates to communication between a single sender and a single
receiver over a network. The term multicast relates to communication between a
10 single sender and multiple receivers.

Multicast Adaptive Bit Rate (mABR) is a technology whereby Live HyperText
Transfer Protocol (HTTP) video content (such as manifests and video/audio
chunks), which are normally delivered over a unicast HTTP using a Transmission
15 Control Protocol (TCP) connection, are instead multicast over the network to a
proxy device located near the end player device. The proxy converts the multicast
stream back into standard HTTP over TCP responses which are served to the
player or requesting device. The player device makes requests via the proxy and
if the proxy has the content (received over multicast) in cache it will return the
20 content, otherwise it will fetch the content from the upstream server (Content
Delivery Network (CDN) node or origin).

SUMMARY OF THE INVENTION

25 According to an example, there is provided a method for providing multicast
adaptive bitrate content to user equipment, the method comprising storing data
representing a mapping from a content identifier to a multicast address for the
content at a proxy configured to distribute the content, the data including a start
value associated with delivery of the content or fragments thereof to the proxy,

receiving a request for content from user equipment, using the data representing the mapping, determining whether the content is available at the proxy or will become available within a threshold period of time using the start time and delivering the content to the user equipment from the proxy. The method can further comprise generating the data representing a mapping from a content identifier to a multicast address for the content at the proxy. The method can further comprise generating the data representing a mapping from a content identifier to a multicast address for the content at a multicast apparatus configured to provide the content or fragments thereof to at least the proxy and transmitting the data from the multicast apparatus to the proxy. Data representing multiple mappings from content identifiers to respective multicast addresses for content can be provided and the method can further comprise selecting a mapping that best matches the request for content from user equipment. The method can further comprise generating a request to join a multicast group associated with the requested content if the proxy is not a member of the group. The method can further comprise selecting a data mapping object from multiple data mapping objects according to a set of heuristics.

According to an example, there is provided a system for providing multicast adaptive bitrate content to user equipment, the system comprising a proxy to store data representing a mapping from a content identifier to a multicast address for the content, the proxy configured to distribute the content, the data including a start value associated with delivery of the content or fragments thereof to the proxy, receive a request for content from user equipment, use the data representing the mapping to determine whether the content is available at the proxy or will become available within a threshold period of time using the start time and deliver the content to the user equipment. The proxy can generate the data representing a mapping from a content identifier to a multicast address for

the content. The system can further comprise a multicast apparatus configured to generate the data representing a mapping from a content identifier to a multicast address for the content and transmit the data to the proxy. The proxy can be an apparatus or a service.

5

According to an example, there is provided a proxy for providing multicast adaptive bitrate content to user equipment, the proxy comprising a cache to store data representing a mapping from a content identifier to a multicast address for the content, the proxy configured to distribute the content, the data including a
10 start value associated with delivery of the content or fragments thereof to the proxy, receive a request for content from user equipment, use the data representing the mapping to determine whether the content is available at the proxy or will become available within a threshold period of time using the start time and deliver the content to the user equipment. The proxy can generate the
15 data representing a mapping from a content identifier to a multicast address for the content. The proxy can select a data mapping object from multiple data mapping objects according to a set of heuristics. The proxy can be a service executable in a memory of user equipment or physical component of user equipment.

20

According to an example, there is provided a computer program product, comprising a computer usable medium having computer readable program code embodied therein, said computer readable program code adapted to be executed to implement a method or providing multicast adaptive bitrate content to user
25 equipment as provided herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic showing a basic operation of functional components in a standard mABR deployment according to an example;

- 5 Figure 2 is a schematic showing internally generated data mapping objects according to an example;

Figure 3 is a schematic showing data mapping objects distributed from a server according to an example;

10

Figure 4 is a flow chart showing proxy criteria for handling of response according to an example;

- 15 Figure 5 is a flow chart showing criteria for selecting a 'best' data mapping object according to an example; and

Figure 6 is a schematic representation of a system according to an example.

DESCRIPTION

- 20 Example embodiments are described below in sufficient detail to enable those of ordinary skill in the art to embody and implement the systems and processes herein described. It is important to understand that embodiments can be provided in many alternate forms and should not be construed as limited to the examples set forth herein.

25

Accordingly, while embodiments can be modified in various ways and take on various alternative forms, specific embodiments thereof are shown in the drawings and described in detail below as examples. There is no intent to limit to the particular forms disclosed. On the contrary, all modifications, equivalents,

and alternatives falling within the scope of the appended claims should be included. Elements of the example embodiments are consistently denoted by the same reference numerals throughout the drawings and detailed description where appropriate.

5

The terminology used herein to describe embodiments is not intended to limit the scope. The articles "a," "an," and "the" are singular in that they have a single referent, however the use of the singular form in the present document should not preclude the presence of more than one referent. In other words, elements referred to in the singular can number one or more, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes," and/or "including," when used herein, specify the presence of stated features, items, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, items, steps, operations, elements, components, and/or groups thereof.

Unless otherwise defined, all terms (including technical and scientific terms) used herein are to be interpreted as is customary in the art. It will be further understood that terms in common usage should also be interpreted as is customary in the relevant art and not in an idealized or overly formal sense unless expressly so defined herein.

Typically, in a mABR system a mechanism to select which multicast group(s) the proxy should be listening on (as it cannot listen to all channels at once due to limited bandwidth) is used and the system can decide when to leave the multicast groups to avoid unnecessary bandwidth usage. The system has to use mechanisms to avoid cache misses and upstream requests caused by the player requesting content that the proxy has not yet received, as well as being able to

handle channels where clients are accessing both live content and time shifted content from the past (e.g. pause live TV, rewind/restart, catch-up services).

In an example, a 'channel map' can be used to define a uniform resource locator (URL) prefix/pattern to identify the 'channel' that is being watched and the corresponding multicast group which should be joined if any requests for that 'channel' are received by the proxy. Here, 'channel' can mean any streaming content. Whilst being efficient in terms of bandwidth used by the control messages this approach is geared for pure live services. If time-shifted content is accessed then this would trigger a multicast join on that 'channel' even though none of the live content delivered over the multicast would be accessed by the client.

In order to avoid players requesting content ahead of what the proxy has received, the last segment from a manifest file can be stripped, thereby keeping the player a chunk behind the proxy. This approach introduces at least a chunk length (2-10s) of additional latency behind live.

According to an example, data representing a mapping from a content identifier to a multicast address for the content can be stored at a proxy configured to distribute the content. The data can include a start value associated with delivery of the content or fragments thereof to the proxy. The data can be used to determine how to handle an incoming request for the content.

The data mapping can be generated shortly before the content is delivered, such as at the time a manifest file containing the new upcoming URIs is transmitted for example. Thus, a proxy will always know about upcoming URIs before the content is requested.

In an example, the proxy can cache the current active data mappings and when a content request is made it can look-up the URI in a cache or memory storing the data mappings. If the URI is stored, the proxy can trigger a multicast join. If the data mapping is not stored, the proxy assumes the content to relate to a time-shifted request and so there is no benefit of joining the multicast group.

According to an example, if the data mapping is stored in the cache the proxy has three paths it can follow:

- 1) If the content is also in cache (that is, it has already been received via multicast) the proxy can serve the content to the client requesting the content.
- 2) If the nominal start (or completion) time is in the future the proxy may 'pause' the client request, wait for the content to be received over multicast, and then return the received content to the client.
- 3) If the nominal completion time is in the past then the proxy can make an upstream unicast request to retrieve the content, as the multicast join is also issued future player requests are likely to result in cache hits.

In this manner, the hit rate on multicast delivery is maximized and unicast usage is minimized, whilst also supporting both time shift and live services being used from the same service, and removing the need to strip the last segment from a manifest files.

Figure 1 is a schematic representation of an mABR deployment according to an example. The Origin/CDN 101 is the source of live content (such as ABR video content for example) that can be streamed over a network, such as the internet and/or a cellular network for example. The mABR server 103 can make requests over http(s) (interface 1) to retrieve the ABR video manifest files and chunks as they become available. It sends (interface 2) the appropriate files over the appropriate multicast group, pacing delivery out at the appropriate rate. The

- player 105 (which physically could be collocated in the same device as the mABR proxy 107, or deployed as a separate box) requests content (interface 3) via the mABR Proxy 107. If the mABR Proxy 107 has previously received and cached content from the multicast stream then it will return the requested item directly.
- 5 Otherwise the mABR proxy 107 will fetch the content (interface 4) from the upstream origin/CDN 101. This may or may not be the same instance as the mABR server 103 but will typically contain files that are identical to those being multicast.
- 10 The request from Player 105 may also trigger the mABR Proxy 107 to join the appropriate multicast group for that stream. With existing mABR devices the selection of the appropriate multicast group is through a simple channel map, where a URL pattern/prefix is compared against the URL being requested.
- 15 According to an example, the proxy 107 can process data mapping objects. These can comprise a mapping from a specific URI to the appropriate multicast address along with nominal start and completion times of when the content is expected to be pushed over multicast. The mappings can either be generated internally by the proxy 107 or be created and distributed by the mABR server 103 (or another
- 20 component).

Figure 2 is a schematic representation of a system according to an example. More particularly, figure 2 shows a system in which a data mapping is generated by the proxy 107 (interface 5).

25

Figure 3 is a schematic representation of a system according to an example. More particularly, figure 3 shows a system in which a data mapping is generated by the server 103 and transmitted to the proxy 107 (interface 5).

In both approaches, multiple techniques to identify what data mapping should be created can be used. For example:

5 Manifest extraction: Before a manifest is delivered to the end client the URLs and metadata within it can be read and converted into mappings with the nominal start and completion time being calculated based upon chunk length and position in the manifest.

10 URI prediction: Some encoder naming schemes use deterministic patterns to define the chunk filename, such as a simple incrementing counter in the name, or based upon the nominal timestamp of that chunk. These patterns can be exploited to predict upcoming filenames and therefore generate appropriate mapping definitions.

15 Explicit linking information: The encoder or origin may embed explicit information about how to generate the following chunk filename, this included adding HTTP headers (such as a 'link' header) or embedded within the file content.

20 Queued object: The server can maintain a queue of objects due to be transmitted and so knows (unlike the client) what is planned to be transmitted for the future and mappings can be generated directly off this list.

25 According to an example, in each approach, when creating the data mapping objects the nominal start and completion time can be calculated based upon the nominal chunk length of the previous and next chunks; as will be described later the start and completion times do not need to be precise but just sufficiently accurate for the heuristics to be joined. In each approach, the appropriate multicast address also needs to be selected, for the first three strategies this could be achieved by matching the mapping URL against a 'channel map' which

matches URL patterns/prefixes against the appropriate multicast address. With the Queued Object strategy the server can explicitly know the target multicast to be used for that object and so has all the information required to generate the data mapping.

5

Request Handling

According to an example, a Player 105 can makes HTTP(s) requests to the mABR Proxy 107. For each request the mABR proxy 107 can make two decisions:

- 10 1. Whether to proxy the request upstream to the Origin/CDN or return content received via multicast;
2. Whether to join or leave any multicast groups.

Figure 4 is a schematic representation of a method according to an example. More specifically, figure 4 depicts a process that can be applied when a content request arrives at a proxy server 107. The process shown allows the proxy 107 to determine if the content is soon to be received, if it is it blocks the client requests (pauses and does not yet return the response) and only starts to deliver the response once the multicast data arrives. Without this behaviour, it would otherwise have been treated as a cache miss and caused a unicast fetch from the CDN/origin to occur, placing more load on the network and upstream systems.

Therefore, according to an example, in block 401 and in response to a content request received at a proxy server 107 from a requesting device 105, if the content URL is in a content cache of the proxy 107 then the cached copy is returned to the device 105. In block 403, if the URL is not in a cache of the proxy 107 then it can simply proxy the request. In block 405, presuming a content URL is in the cache of the proxy 107, the best entry from the cache is selected and a multicast join is issued if the proxy is not already a member of the multicast group. In block

407, if the mapping indicates the multicast has not yet completed, the http request from the client is blocked and the content is delivered from cache as (or after) the multicast stream arrives. In block 409, if the content has already completed but is not in the content cache then the request can be proxied over
5 HTTP to the CDN/origin 101.

In some deployments the same URL may be multicast out multiple times, either on the same or different multicast addresses. As noted, the process of figure 4 handles this by selecting the 'best' candidate from the cache (block 405). In this
10 connection, figure 5 is a schematic representation showing some criteria that can be used to determine a suitable data mapping according to an example. The criteria can be:

1. Most complete already started data mapping on an already joined
15 multicast that is in the content cache; or
2. Earliest starting data mappings on an already joined multicast channels which is due to start after now but before now + max_block_time; or
3. Earliest starting data mapping on another multicast channels due to start after now + multicast_join_latency but before now + max_block_time with a
20 trigger_join of Future or Always; or
4. Latest starting data mapping on another multicast channel already started but due to finish after now + multicast_join_latency + minimum_partial_period with a trigger join of Always.

In an example, the max_block_time is the maximum duration to block a client whilst waiting for content delivery to start; multicast_join_latency is the nominal latency to expect when joining the multicast; minimum_partial_period is the minimum amount of time it is worthwhile to receive over multicast. The value of
5 max_block_time can be tuned and higher values may increase channel tune time (blocking the client for longer) but minimize unicast traffic.

Data mapping object Lifecycle

10 The mABR Proxy 107 can receive or generate data mapping objects which can be stored in a data mapping object cache. If the mABR Proxy 107 is generating the objects internally (figure 2) then typically they would only be for the currently played channel(s) and bitrate(s). If it is receiving them from the mABR Server (figure 3) then it may receive data mapping objects for other channels and bitrates
15 as well.

In an example, the removal of data mapping objects from the cache can be linked to the eviction of content from a Content Cache which typically operates with FIFO semantics (first in first out). That is, when an item is evicted from the Content
20 Cache its corresponding data mapping object can be identified. All data mapping objects with an older or equal nominal completion time than the content's data mapping object can be evicted at the same time.

Using this mechanism old data mapping objects are only retained for as long as
25 content is likely to be cached for. This reduces client bandwidth usage because if a client requests content that is older than the content cache retention period no data mapping object would be found and therefore a multicast join would not be issued.

If the multicast join were issued, client bandwidth would be wasted as the content received from that multicast group is likely to be evicted before the player would actually request the content.

In addition, in a household with multiple active players/devices for example, the proxy content cache is shared between all players. Thus, if the proxy starts caching a second stream then the retention period of the content cache will reduce (nominally by half if the bitrates are the same), if the first user was watching behind live this reduction will sometimes result in the first user also no longer receiving cache hits (as their content is now evicted before they can watch it) and therefore increasing unicast acquisition.

Multicast Joining/Leaving

As noted above, multicast joins can be triggered when an HTTP request is received from a device 105 and a 'best' data mapping object is selected. If the data mapping object is for a multicast group which the proxy 107 is not currently a member of, a multicast join can be issued. This mechanism can be modified by either introducing a delay before the join is issued (n requests over a time period before the join is issued), or based upon additional properties on the data mapping object, these could include a time threshold, or 'trigger join' attributes which signals how the proxy should join based upon the data mapping object. Possible values of the 'trigger join' could include 'always', 'never' or 'future only', causing the proxy respectively to: always join if needed, never join based upon that data mapping object, or only join if the data mapping object is nominally in the future.

25

Figure 6 is a schematic representation of a system according to an example. A content server 603 can provide content 601 to a proxy apparatus 607. As noted above, the proxy 607 may be a standalone apparatus or may be part of or provided with user equipment 609, which can be a player device, which may be

used to request the content 601. In an example, the proxy 607 can be a proxy service, which may be provided as part of a virtualised system implemented using multiple virtual machines.

- 5 In an example, the content 601 can be identified using a data mapping object 611. That is, as described above, a data mapping object 611 can comprise a mapping from a specific URI to the appropriate multicast address of the content 601 along with nominal start and completion times of when the content 601 (or fragments thereof) is expected to be pushed or delivered by multicast. The
- 10 mappings can either be generated internally by the proxy 607 or be created and distributed by a mABR server 608, which may be a multicast apparatus configured to provide the content or fragments thereof to at least the proxy (or another component). In either case, the data mapping object 611 is stored in a cache 613 of the proxy 607.

15

- The present inventions can be embodied in other specific apparatus and/or methods. The described embodiments are to be considered in all respects as illustrative and not restrictive. In particular, the scope of the invention is indicated by the appended claims rather than by the description and figures herein. All
- 20 changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS

1. A method for providing multicast adaptive bitrate content to user equipment, the method comprising:
 - 5 storing data representing a mapping from a content identifier to a multicast address for the content at a proxy configured to distribute the content, the data including a start value associated with delivery of the content or fragments thereof to the proxy;
receiving a request for content from user equipment;
 - 10 using the data representing the mapping, determining whether the content is available at the proxy or will become available within a threshold period of time using the start time; and
delivering the content to the user equipment from the proxy.
- 15 2. A method as claimed in claim 1, further comprising:
generating the data representing a mapping from a content identifier to a multicast address for the content at the proxy.
3. A method as claimed in claim 1, further comprising:
 - 20 generating the data representing a mapping from a content identifier to a multicast address for the content at a multicast apparatus configured to provide the content or fragments thereof to at least the proxy; and
transmitting the data from the multicast apparatus to the proxy.
- 25 4. A method as claimed in any preceding claim, wherein data representing multiple mappings from content identifiers to respective multicast addresses for content is provided, the method further comprising:
selecting a mapping that best matches the request for content from user equipment.

5. A method as claimed in claim 4, further comprising:
generating a request to join a multicast group associated with the requested content if the proxy is not a member of the group.
- 5 6. A method as claimed in any preceding claim, further comprising:
selecting a data mapping object from multiple data mapping objects according to a set of heuristics.
7. A system for providing multicast adaptive bitrate content to user
10 equipment, the system comprising:
a proxy to store data representing a mapping from a content identifier to a multicast address for the content, the proxy configured to:
distribute the content, the data including a start value associated with delivery of the content or fragments thereof to the proxy;
15 receive a request for content from user equipment;
use the data representing the mapping to determine whether the content is available at the proxy or will become available within a threshold period of time using the start time; and
deliver the content to the user equipment.
- 20 8. A system as claimed in claim 7, wherein the proxy is configured to generate the data representing a mapping from a content identifier to a multicast address for the content.
- 25 9. A system as claimed in claim 7, further comprising a multicast apparatus configured to generate the data representing a mapping from a content identifier to a multicast address for the content and transmit the data to the proxy.

10. A system as claimed in any of claims 7 to 9, wherein the proxy is an apparatus or a service.

11. A proxy for providing multicast adaptive bitrate content to user
5 equipment, the proxy comprising a cache to store data representing a mapping from a content identifier to a multicast address for the content, the proxy configured to:

 distribute the content, the data including a start value associated with delivery of the content or fragments thereof to the proxy;

10 receive a request for content from user equipment;

 use the data representing the mapping to determine whether the content is available at the proxy or will become available within a threshold period of time using the start time; and

 deliver the content to the user equipment.

15

12. A proxy as claimed in claim 11, wherein the proxy is configured to generate the data representing a mapping from a content identifier to a multicast address for the content.

20 13. A proxy as claimed in claim 11 or 12, wherein the proxy is configured to select a data mapping object from multiple data mapping objects according to a set of heuristics.

14. A proxy as claimed in any of claims 11 to 13, wherein the proxy is a service
25 executable in a memory of user equipment or physical component of user equipment.

15. A computer program product, comprising a computer usable medium having computer readable program code embodied therein, said computer

readable program code adapted to be executed to implement a method or providing multicast adaptive bitrate content to user equipment as claimed in any of claims 1 to 6.

5

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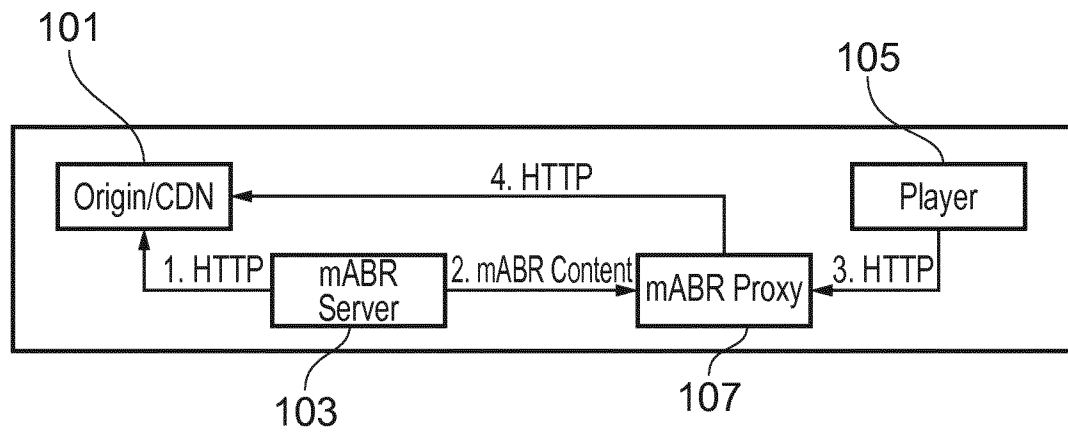


FIG. 1

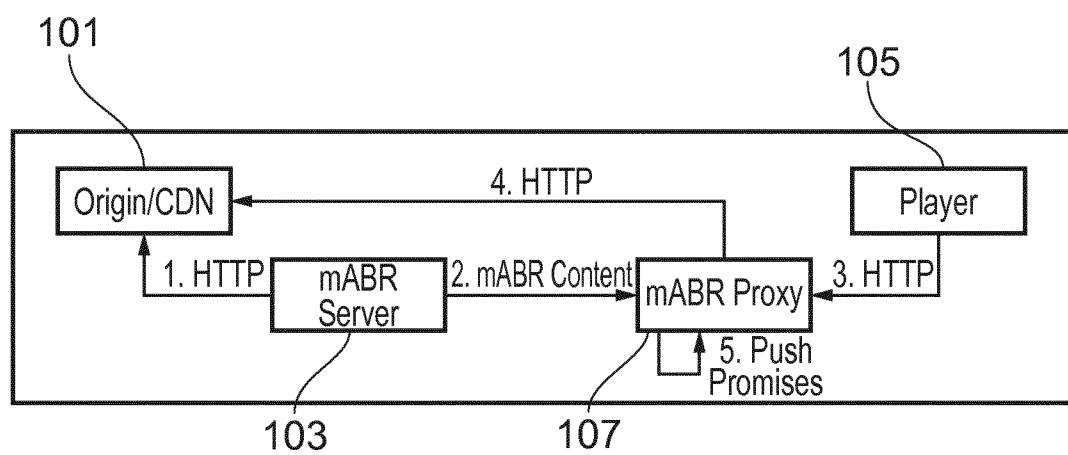


FIG. 2

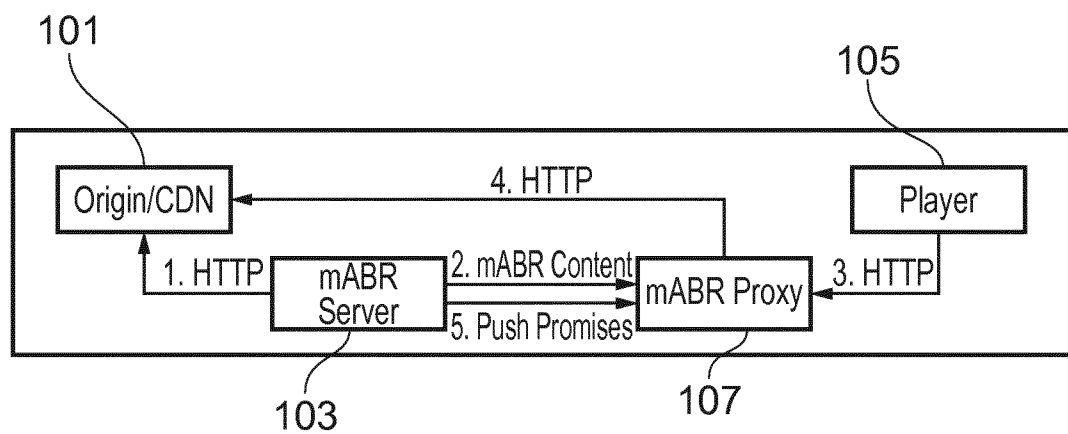


FIG. 3

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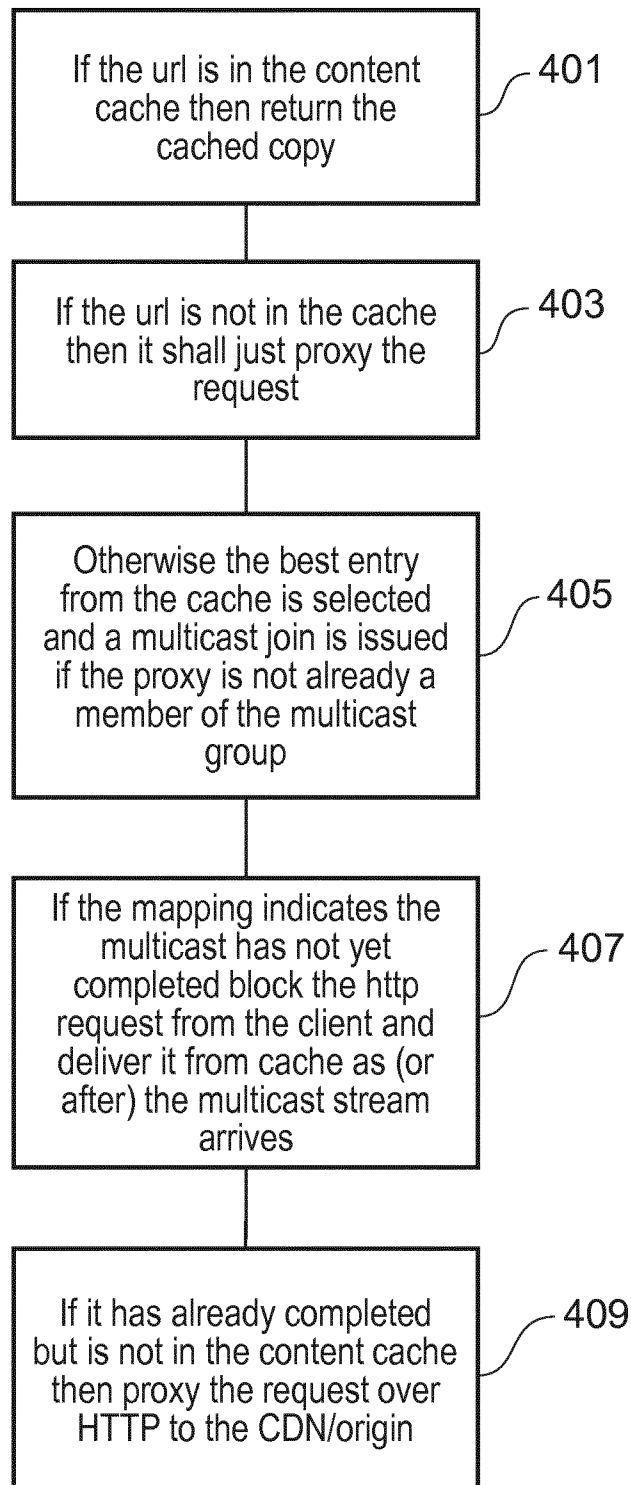


FIG. 4

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1. Most complete already started push promise on an already joined multicast that is in the content cache.
2. Earliest starting push promises on an already joined multicast channels which is due to start after now but before $\text{now} + \text{max_block_time}$
3. Earliest starting push promise on another multicast channels due to start after $\text{now} + \text{multicast_join_latency}$ but before $\text{now} + \text{max_block_time}$ with a trigger_join of Future or Always
4. Latest starting push promise on another multicast channel already started but due to finish after $\text{now} + \text{multicast_join_latency} + \text{minimum_partial_period}$ with a trigger join of Always

FIG. 5

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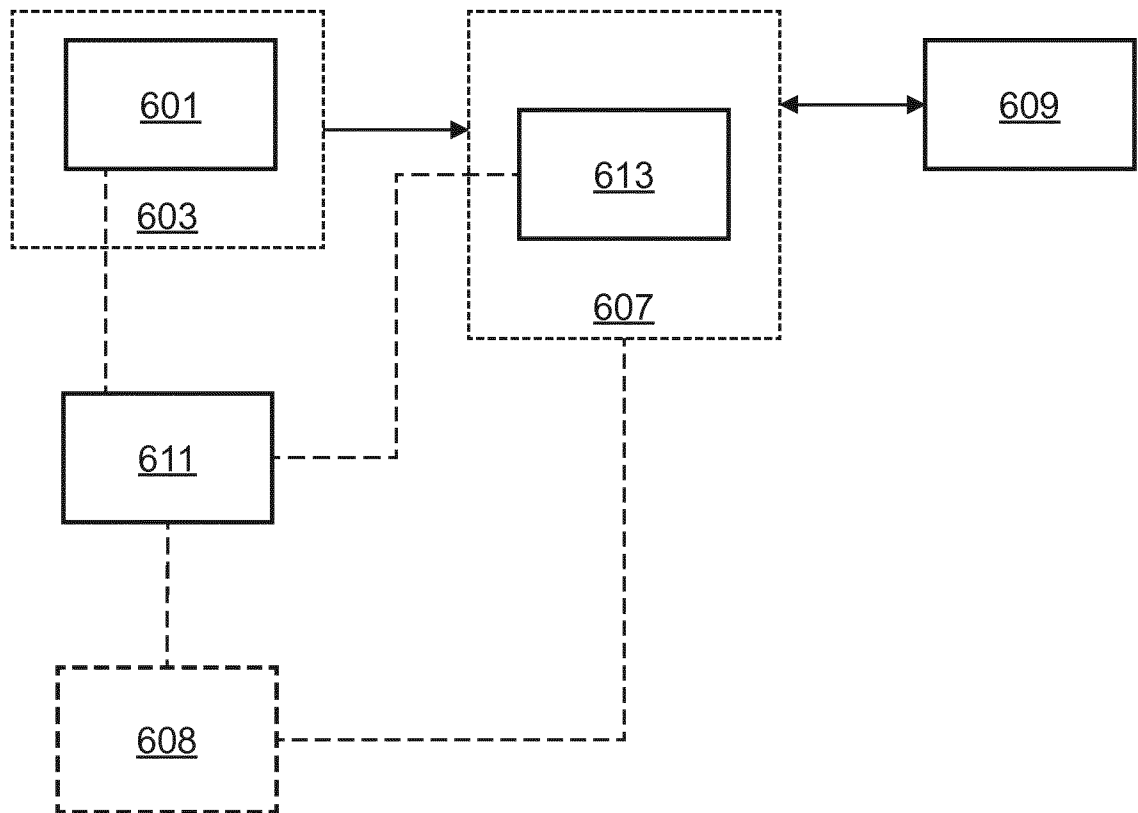


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2018/058277

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04L29/06 H04L29/08
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)

H04L

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/294898 A1 (WHEELOCK IAN [IE]) 6 October 2016 (2016-10-06)	1,2,5,7, 8,10-12, 14,15
Y	paragraph [0018] - paragraph [0021] paragraph [0060] - paragraph [0080] paragraph [0105] - paragraph [0107] paragraph [0122] - paragraph [0150] figures 1A, 1B, 1C -----	3,4,6,9, 13
Y	US 2012/230333 A1 (WANG JINHUI [CN]) 13 September 2012 (2012-09-13) paragraph [0025] - paragraph [0039] figures 4-6 -----	3,9
Y	US 2014/355603 A1 (LI YONG [US] ET AL) 4 December 2014 (2014-12-04) paragraph [0012] - paragraph [0023] figure 1 -----	4,6,13



Further documents are listed in the continuation of Box C.



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INTERNATIONAL SEARCH REPORT

Information on patent family members

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