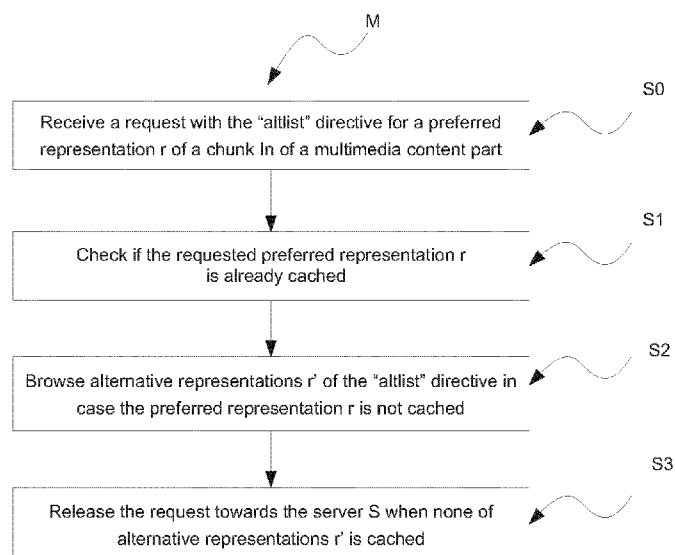




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[Continued on next page]

(54) **Title:** METHOD FOR PROVIDING A CONTENT PART OF A MULTIMEDIA CONTENT TO A CLIENT TERMINAL, CORRESPONDING CACHE

**Figure 4**

(57) **Abstract:** According to the invention, the method for providing a content part of a multimedia content to a client terminal, a cache being arranged along the transmission path between the client terminal and a remote server, several representations of said content part being available, is characterized in that it comprises the successive steps of: - receiving (S0), from the client terminal, a request for a given representation of said content part belonging to a set of allowable representations selected among said available representations of the content part, said request further comprising a list of alternative representations of the set and returning one of said alternative representations when cached; - checking (S1) if said given representation is stored in the cache; - in case said given representation is not cached, browsing (S2) alternative representations of the list; - in case neither the given representation nor any of the listed alternative representations is cached, sending a response message to the client terminal (C).



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Method for providing a content part of a multimedia content to a client terminal, corresponding cache.

FIELD OF THE INVENTION

5 The present invention relates generally to the domain of the adaptive streaming technology over, for instance but not exclusively, HTTP (HyperText Transfer Protocol) and, in particular, to a method for providing a content part of a multimedia content to a client terminal, a cache being arranged along the transmission path between the client terminal and a remote server.

BACKGROUND OF THE INVENTION

10 This section is intended to introduce the reader to various aspects of art, which may be related to various aspects of the present invention that are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these
15 statements are to be read in this light, and not as admissions of prior art.

Adaptive streaming over HTTP (also called multi-bitrate switching) is quickly becoming a major technology for multimedia content distribution. Among the HTTP adaptive streaming protocols which are already used, the most famous are the HTTP Live Streaming (HLS) from Apple, the Silverlight Smooth Streaming (SSS)
20 from Microsoft, the Adobe Dynamic Streaming (ADS) from Adobe and the Dynamic Adaptive Streaming over HTTP (DASH) developed by 3GPP within the SA4 group.

When a client terminal wishes to play an audiovisual content (or A/V content) in adaptive streaming, it first has to get a file describing how this A/V content might be obtained. This is generally done through the HTTP protocol by getting a
25 describing file, so-called manifest, from an URL (Uniform Resource Locator), but can be also achieved by other means (e.g. broadcast, e-mail, SMS and so on). The manifest basically lists the available representations (also called instances or versions) of such an A/V content (in terms of bitrate, resolution and other properties); one representation per quality level (bitrate). Each representation is
30 made of a series of chunks of equal duration – accessible by a separate URL – and has a set of descriptive elements attached for selection by the client. Said manifest is generated in advance and delivered to the client terminal by, for instance, a remote server.

Indeed, the stream of data corresponding to the A/V content is available on an HTTP server with different qualities. The highest quality is associated with a high bitrate; the lowest quality is associated with a low bitrate. This allows distribution to many different terminals which might be subject to highly varying network conditions.

The whole data stream of each representation is divided into chunks of equal duration which are made such that a client terminal may smoothly switch from one quality level to another between two chunks. As a result, the video quality may vary while playing but rarely suffers from interruptions (also called freezes).

At the client side, the chunks are selected based on a measure of the available bandwidth of the transmission path. In particular, a client terminal usually requests the representation of a chunk corresponding to a bitrate encoding and thus a quality compliant with the measured bandwidth.

When a cache is along the transmission path between a client terminal and a remote server which frequently occurs, one representation of a given chunk may already be stored in said cache, in case another client has previously requested the same chunk with the same representation or in case a Content Delivery Network (CDN) has already provisioned the chunk in the cache. Thus, the response to an HTTP request for said given chunk is faster than if the chunk comes from the remote server and duplicate transmission can be avoided, effectively saving network resources.

Nevertheless, the HTTP adaptive streaming appears not to be cache friendly (or at least less cache friendly than the so called layered base switching as for instance H264-SVC). Indeed, if a first client terminal requests a representation r of a given chunk and a second client terminal – sharing a part of the transmission path with said first client terminal and a cache – requests a representation r' of said given chunk (at a higher or lower quality), then the cache is not hit leading to higher load on the network segment between the cache and the server with the risk of causing congestion. The benefits of caching are then completely annihilated and caches are currently unable to improve this situation.

The present invention focuses on preventing network congestions and, in particular, attempts to operate caches possibly located along the transmission path between a client terminal and one or several remote servers.

SUMMARY OF THE INVENTION

The invention concerns a method for providing a content part of a multimedia content to a client terminal, a cache being arranged along the transmission path between the client terminal and a remote server, several representations of said content part being available,

5 which is remarkable in that it comprises:

- receiving, from the client terminal, a request for a given representation of said content part, belonging to a set of allowable representations selected among, said request further comprising a list of alternative representations of the set;
- checking if said given representation is stored in the cache;
- 10 - in case said given representation is not cached, browsing alternative representations listed in said directive and returning one of said alternative representations when cached;
- in case neither the given representation nor any of the listed alternative representations is cached, sending a response message to the client terminal.

15 Thus, thanks to the present invention, it is possible to decrease the end-to-end traffic between a client terminal (i.e. an HTTP adaptive streaming client terminal) and the corresponding origin server by means of caching, that is increasing the number of cache hits. To this end, a cache is configured to support a directive of the request sent by a client terminal, so that it can fetch alternative
20 representations included in this directive when the given representation is not cached. It can then lead to less traffic between the client terminal and the original server and, as a consequence, less congestion. Thus, the present invention can provide a better user experience to the end user, as limiting the need to download chunks from the server.

25 In a preferred embodiment, the alternative representations are browsed in order of preference, said alternative representations being listed, for instance, in order of decreasing preference.

Besides, said method can further comprise the step of releasing said request when none of the alternative representations is cached in said cache.

30 In addition, each alternative representation has preferably a corresponding bitrate lower than the one of the given representation. Naturally, in a variant, at least one alternative representation might have a corresponding bitrate higher than the one of the given representation.

Moreover, each allowable representation of the set can advantageously have a corresponding bitrate at most equal to the bandwidth of the transmission path between the client terminal and the remote server.

5 In another aspect of the preferred embodiment, the transmission protocol used being HTTP, the request is an HTTP request and the Cache Control extension of said HTTP request comprises said list of alternative representations.

In particular, when the transmission protocol used is HTTP, said list of alternative representations is included within the cache control extension of said HTTP request.

10 Furthermore, the present invention also concerns a cache configured for providing a content part of a multimedia content to a client terminal, said cache being arranged along the transmission path between the client terminal and a remote server, several representations of said content part being available.

According to the present invention, said cache comprises:

- 15 – an interface module for receiving, from the client terminal, a request for a given representation of said content part belonging to a set of allowable representations selected among said available representations, said request further comprising a list of alternative representations of the set and additional information such that the interface module returns the given representation or
- 20 a listed alternative representation, if cached, or a response message in case neither the given representation nor any of the listed alternative representations is cached;
- a controlling module for checking if said given representation is stored;
- a browsing module formed to browse the list of alternative representations, in
- 25 case said given representation is not cached.

Preferably, the alternative representations can be browsed in order of preference.

Moreover, said cache can be further configured for releasing said request when none of the alternative representations is cached.

30 Certain aspects commensurate in scope with the disclosed embodiments are set forth below. It should be understood that these aspects are presented merely to provide the reader with a brief summary of certain forms the invention might take and that these aspects are not intended to limit the scope of the invention. Indeed, the invention may encompass a variety of aspects that may not be set forth below.

The invention will be better understood and illustrated by means of the following embodiment and execution examples, in no way limitative, with reference to the appended figures on which:

- Figure 1 is a schematic diagram of a Client-Server network architecture wherein the present invention might be implemented;
- Figure 2 is a block diagram of an example of a client terminal according to a preferred embodiment of the present invention;
- Figure 3 is a block diagram of an example of a cache according to a preferred embodiment of the present invention;
- Figure 4 is a flow chart illustrating the method for retrieving a representation of a given chunk implemented by the cache of Figure 3.

In Figures 1 to 3, the represented blocks are purely functional entities, which do not necessarily correspond to physically separate entities. Namely, they could be developed in the form of software, hardware, or be implemented in one or several integrated circuits, comprising one or more processors.

Wherever possible, the same reference numerals will be used throughout the figures to refer to the same or like parts.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

It is to be understood that the figures and descriptions of the present invention have been simplified to illustrate elements that are relevant for a clear understanding of the present invention, while eliminating, for purposes of clarity, many other elements found in typical digital multimedia content delivery methods and systems. However, because such elements are well known in the art, a detailed discussion of such elements is not provided herein. The disclosure herein is directed to all such variations and modifications known to those skilled in the art.

According to a preferred embodiment, the present invention is depicted with regard to the HTTP adaptive streaming protocol. Naturally, the invention is not restricted to such a particular environment and other adaptive streaming protocol could of course be considered and implemented.

As depicted in Figure 1, the Client-Server network architecture, wherein the present invention might be implemented, comprises a client terminal C, a gateway GW and one or more HTTP servers S (only one is represented on Figure 1).

The client terminal C – connected to the gateway GW through a first network N1 (such as a home network or an enterprise network) – may wish to request a multimedia content stored on a remote server S through a second network N2 (such

as the Internet network). The first network N1 is connected to the second network N2 thanks to the gateway GW.

The HTTP server S streams chunks to the client terminal C, upon the client request, using HTTP adaptive streaming protocol over one or more TCP/IP
5 connections.

According to the preferred embodiment as described in Figure 2, the client terminal C comprises at least:

- an interface of connection 1 (wired and/or wireless, as for example Wi-Fi, Ethernet, etc.) to the first network N1;
- 10 – a communication module 2 containing the protocol stacks to communicate with the HTTP server S. In particular, the communication module 2 comprises the TCP/IP stack well known in the art. Of course, it could be any other type of network and/or communicating means enabling the client terminal C to communicate with the HTTP server S;
- 15 – an adaptive streaming module 3 which receives the HTTP streaming multimedia content from the HTTP server S. It continually selects the representation of a chunk whose the corresponding bitrate better matches constraints as described hereinafter;
- a video player 4 adapted to decode and render the multimedia content;
- 20 – one or more processor(s) 5 for executing the applications and programs stored in a non-volatile memory of the client terminal C;
- storing means 6, such as a volatile memory, for buffering the chunks received from the HTTP server S before their transmission to the video player 4;
- an internal bus B1 to connect the various modules and all means well known
25 to the skilled in the art for performing the generic client terminal functionalities.

As an example, the client terminal C is a portable media device, a mobile phone, a tablet or a laptop. Naturally, the client terminal C might not comprise a complete video player, but only some sub-elements such as the ones for demultiplexing and decoding the media content and might rely upon an external
30 means to display the decoded content to the end user. In this case, the client terminal C is a HTTP Adaptive Streaming (HAS) capable video decoder, such as a set-top box.

According to the preferred embodiment as described in Figure 1, the gateway GW comprises a cache R, which is arranged along the transmission path
35 between the client terminal C and a server S. In a variant, said cache R might be

arranged in a proxy of the first network N1 or in any other location along the transmission path.

In the following, it is assumed that the client terminal C requests an HTTP Adaptive Streaming (HAS) multimedia content to the remote server S, said HAS multimedia content being available in several representations made of a series of chunks. The quality of each representation should be understood as related to media encoding quality, media encoding type (e.g. 2D versus 3D), media encoding color scheme, etc...

To this end, as shown in Figure 2, the client terminal C further comprises:

- 10 – a bandwidth estimator 7 configured for estimating the bandwidth of the transmission path;
- a selection module 8 configured for determining a set of allowable representations the client terminal C might request. The allowable representations are selected among the available representations of a given chunk I_n of the multimedia content, as listed in the associated manifest. In particular, the determination – by the module 8 – of the set of allowable representations of the given chunk I_n can be based on one or several performance criteria as for instance:
 - the bandwidth estimated by the estimator 7;
 - 20 ▪ the capabilities of the client terminal C;
 - the representation of the previously requested chunk I_{n-1} ;
 - the quality of experience required by an end user of the client terminal C.

Obviously, the selection module 8 might be, in a variant, integrated within the adaptive streaming module 3.

- 25 It might be appreciated that the meaning of « allowable » representations depends on the implementation. Indeed, it may mean upgraded or downgraded quality representations of a given chunk I_n by comparison with the representation of the previously requested chunk I_{n-1} .

- 30 If the requested representation of a given chunk I_n has a corresponding quality significantly lower (i.e. visible by an end user) than the one of the representation of the previously requested chunk I_{n-1} , the selection module 8 might be configured not to attempt to further downgrade the quality in operating potential cached chunk, except if constrained by the available bandwidth.

- 35 In an illustrative but non-limitative example compliant with the present invention, the allowable representations of a given chunk I_n (selected from the

available representations listed in the manifest) have a corresponding bitrate (related to a given quality) at most equal to the estimated bandwidth. In addition, the bitrate of allowable representations of the set might also be at least equal to a defined threshold, under which quality is not acceptable by an end user of the client terminal C.

Obviously, as a variant or as a complement, the determined set of allowable representations can comprise one or more representations with a bitrate higher than the estimated bandwidth, in order to try to fetch a representation already stored in the cache R.

Besides, the adaptive streaming module 3 is configured to request a preferred representation r of a given chunk I_n of the HAS multimedia content, from the set of allowable representations. For instance, the preferred representation r of the chunk I_n might correspond to the representation having an associated bitrate just lower than the estimated bandwidth.

To this end, the communication module 2 sends an HTTP request wherein the Cache Control extension of its header comprises the directive "altlist", which allows the client terminal C to list, in order of preference or priority, alternative representations r' that can be returned by cache R in case the preferred representation r is not cached.

The alternative representations r' of the "altlist" directive preferably correspond to the allowable representations of the determined set. Obviously, additional representations (for instance, having a bitrate higher than the estimated bandwidth) might be added.

Hereinafter is an example of such an HTTP request including the "altlist" directive:

```
GET /hi/fileSequence2681.ts HTTP/1.1
Host: example.com
Cache-Control:altlist=http://example.com/med/fileSequence2681.ts,http://example.com/low/fileSequence2681.ts
```

According to the preferred embodiment, it might be appreciated that the cache R supports the "altlist" directive, meaning that it is configured to interpret its content. Such a cache R is hereinafter called "smart" cache.

To this end, according to the preferred embodiment, and as shown in Figure 3, the smart cache R comprises:

- a storage module 9, such as a volatile memory and/or a permanent memory, for storing chunks of multimedia contents received from one or more servers S before their transmission to the client terminal C, requesting such multimedia contents;
- 5 – an interface module 10 configured to receive, from the client terminal C, an HTTP request for a preferred representation r of the content part, said preferred representation r belonging to the set of allowable representations. It is assumed that said HTTP request indicates – within the “altlist” directive – alternative representations r' which might be accepted as replacement by the
- 10 client terminal C in case the preferred representation r is not cached;
- a controlling module 11 formed to check whether or not the smart cache R already has the requested preferred representation r ; and
- a browsing module 12 adapted to browse in order of preference alternative representations listed in the “altlist” directive of the HTTP request sent by the
- 15 client terminal C, in case the preferred representation r is not cached. In a variant, the controlling module and the browsing module form only one module.

Upon receipt of such an HTTP request for a preferred representation r of a given chunk I_n from the client terminal C, the controlling module 11 of the smart

20 cache R checks whether or not said preferred representation r is cached:

- if cached, the smart cache R returns the preferred representation r to the client terminal C;
- if not cached, the browsing module 12 browses the “altlist” directive of the HTTP request to successively checks, in order of preference, whether or not
- 25 one alternative representation r' is cached.

When such an alternative representation r' of the “altlist” directive is cached, the smart cache R returns said alternative representation r' to the client terminal C.

In case none of the alternative representations r' of the “altlist directive” is cached, the smart cache R is configured to release the HTTP request sent by the

30 client terminal C towards the server S.

The released HTTP request might then be intercepted by a next cache along the transmission path between the smart cache R and the remote server S, so that, if said next cache is a smart cache, it behaves as the smart cache R. Otherwise (the next cache does not support the “altlist” directive), it might return an error message

35 or might release the HTTP request towards the server S.

As illustrated in Figure 4, according to said preferred embodiment, the cache R is configured to implement the following mechanism M for providing a requested representation of a given chunk I_n of an HAS multimedia content to the client terminal C. Said mechanism M comprises the steps of:

- 5 – receiving (step S0), from the client terminal C, an HTTP request for a preferred representation r of the given chunk I_n part belonging to a set of allowable representations as previously defined. The HTTP request further comprises the “altlist” directive listing alternative representations of the set;
- checking (step S1) if the preferred representation r is stored in the storage
10 module 9;
- browsing (step S2), in order of preference, alternative representations r' listed in said “altlist” directive in case the preferred representation r is not cached;
- releasing (step S3) the HTTP request towards the server S when none of the alternative representations r' is cached in the storage module 9 of the smart
15 cache R.

In a variant of the preferred embodiment, the Cache Control extension of an HTTP request, sent by the client terminal C, might further comprise an additional directive (defining additional information), named “only_if_cached”. The “altlist” directive keeps priority over the “only_if_cached” directive of the Cache Control
20 header. Hereinafter is an example of such an HTTP request with the above mentioned directives:

```
GET /hi/fileSequence2681.ts HTTP/1.1
Host: example.com
Cache-Control: only_if_cached,altlist=http://example.com/med/fileSequence268
25     1.ts,http://example.com/low/fileSequence2681.ts
```

In this variant, upon receipt of such an HTTP request (including both directives “only_if_cached” and “altlist”) for a preferred representation r of a given chunk I_n , the smart cache R checks whether or not said preferred representation r is cached:

- 30 – if cached, the smart cache R returns the preferred representation r to the client terminal C;
- if not cached, the browsing module 12 browses the “altlist” directive of the HTTP request to successively checks, in order of preference, whether or not one alternative representation r' is cached.

When such an alternative representation r' of the “altlist” directive is cached, the smart cache R returns said alternative representation r' to the client terminal C.

In case none of the alternative representations r' of the “altlist directive” is cached, the smart cache R is then configured to return an error message (for instance “http/1.1 504 altlist supported”), thanks to the “only_if_cached” directive, to both indicate that:

- the preferred representation r is not cached;
- the cache R supports the “altlist” directive, so that it can be derived from the receipt of such an error message that none of the alternative representations r' of the “altlist” directive is cached.

In a further step, the client terminal C might send a new request to the remote server S to retrieve the preferred representation r of the given chunk I_n , directly from the server S. To this end, neither the “only_if_cached” directive, nor the “altlist” directive is used in the header of this new request. Obviously, this new request might also comprise only the “altlist” directive, without the “only_if_cached” directive.

References disclosed in the description, the claims and the drawings may be provided independently or in any appropriate combination. Features may, where appropriate, be implemented in hardware, software, or a combination of the two.

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

This invention having been described in its preferred embodiment, it is clear that it is susceptible to numerous modifications and embodiments within the ability of those skilled in the art and without the exercise of the inventive faculty. Accordingly, the scope of the invention is defined by the scope of the following claims.

In the claims hereof, any element expressed as a means for performing a specified function (e.g. adaptive streaming module 3, bandwidth estimator 7, selection module 8, controlling module 11, browsing module 12, etc.) is intended to encompass any way of performing that function including, for example, a) a combination of circuit elements (for instance one or more processors) 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 present principles as defined by such claims reside 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.

CLAIMS

1. Method for providing a content part of a multimedia content to a client terminal (C), a cache (R) being arranged along the transmission path between the client terminal (C) and a remote server (S), several representations of said content part being available,
5 comprising:

- receiving (S0), from the client terminal (C), a request for a given representation of said content part, belonging to a set of allowable representations selected among said available representations, said request
10 further comprising a list of alternative representations of the set;
- checking (S1) if said given representation is stored in the cache (R);
- in case said given representation is not cached, browsing (S2) alternative representations listed and returning one of said alternative representations
15 when cached;
- in case neither the given representation nor any of the listed alternative representations is cached, sending a response message to the client terminal (C).

20 2. Method according to claim 1, wherein the alternative representations are browsed in order of preference.

3. Method according to claim 2 or 3, further comprising the step of releasing (S3) said request when none of the alternative representations is cached in said
25 cache (R).

4. Method according to any of claims 1 to 3, wherein each alternative representation has a corresponding bitrate lower than the one of the given representation.

30

5. Method according to claim 4, wherein each allowable representation of the set has a corresponding bitrate at most equal to the bandwidth of the transmission path between the client terminal (C) and the remote server (S).

6. Method according to any of claims 1 to 5, wherein, the transmission protocol used being HTTP, the request is an HTTP request and the Cache Control extension of said HTTP request comprises said list of alternative representations.

5 7. Method according to any one of claims 1 to 6, wherein, when the transmission protocol used is HTTP, said list of alternative representations is included within the cache control extension of said HTTP request.

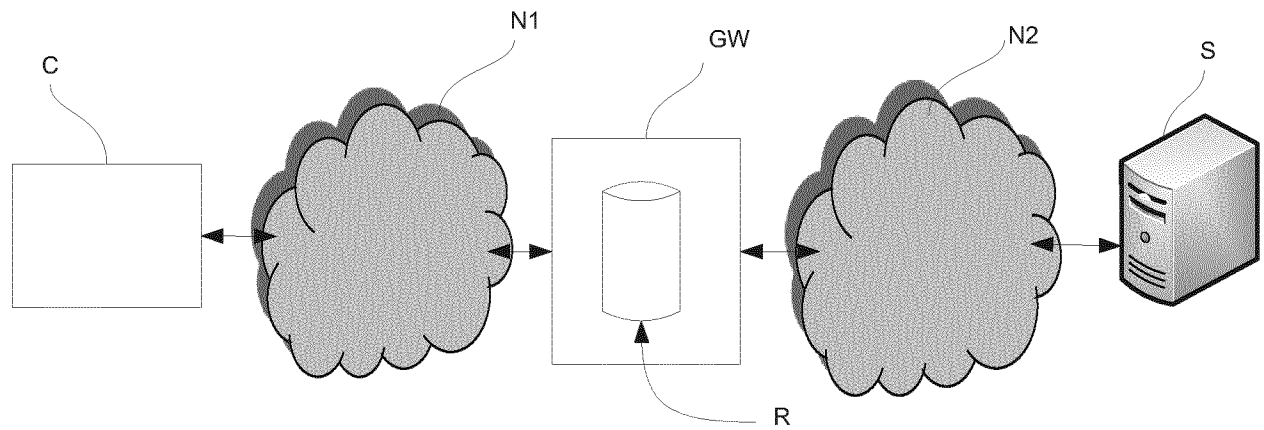
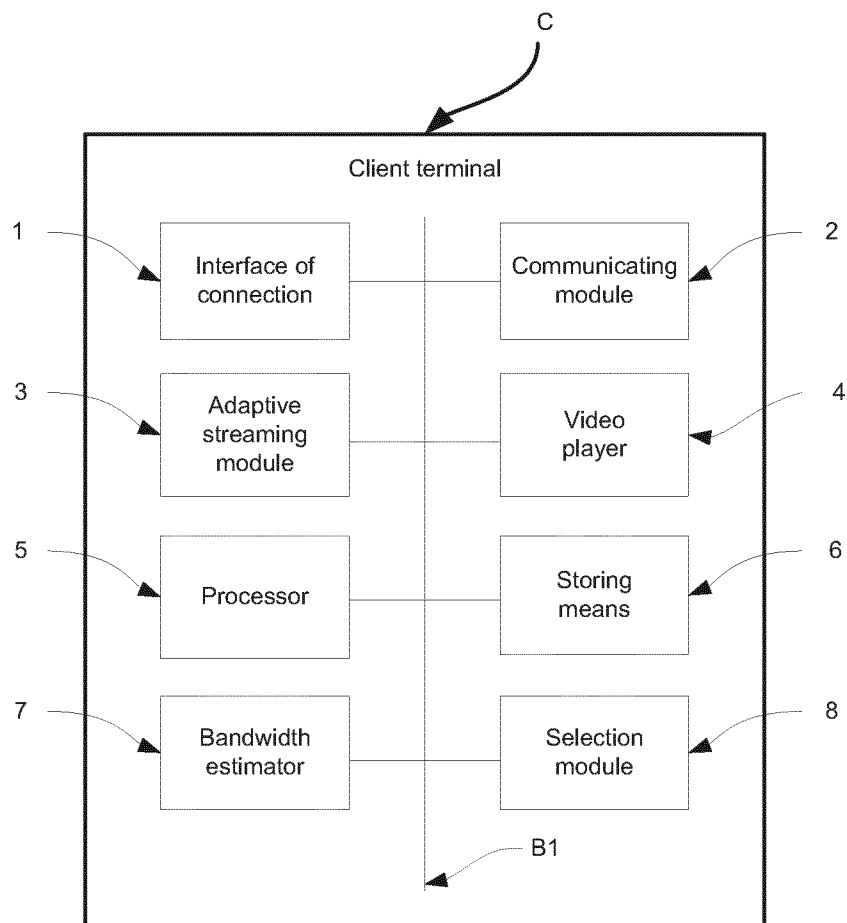
10 8. Cache configured for providing a content part of a multimedia content to a client terminal (C), said cache (R) being arranged along the transmission path between the client terminal (C) and a remote server (S), several representations of said content part being available,
characterized in that it comprises:

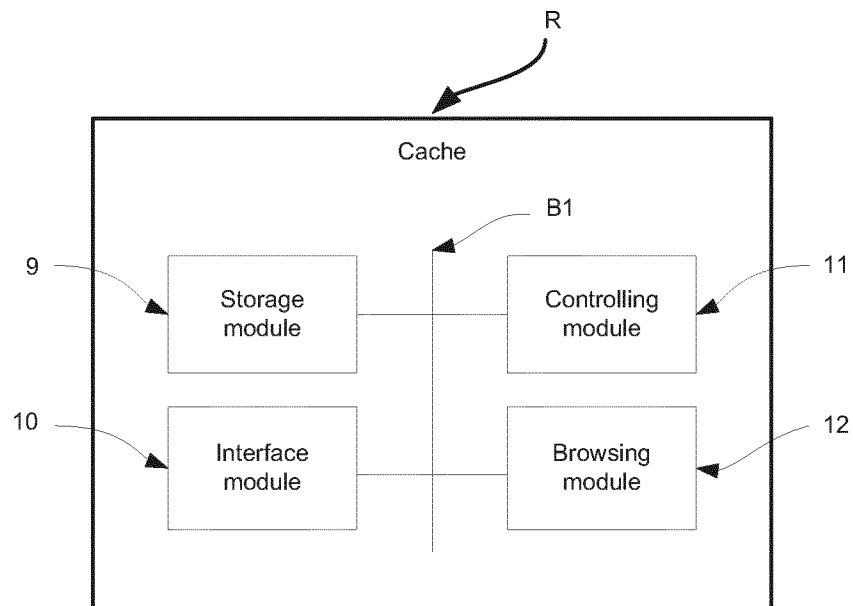
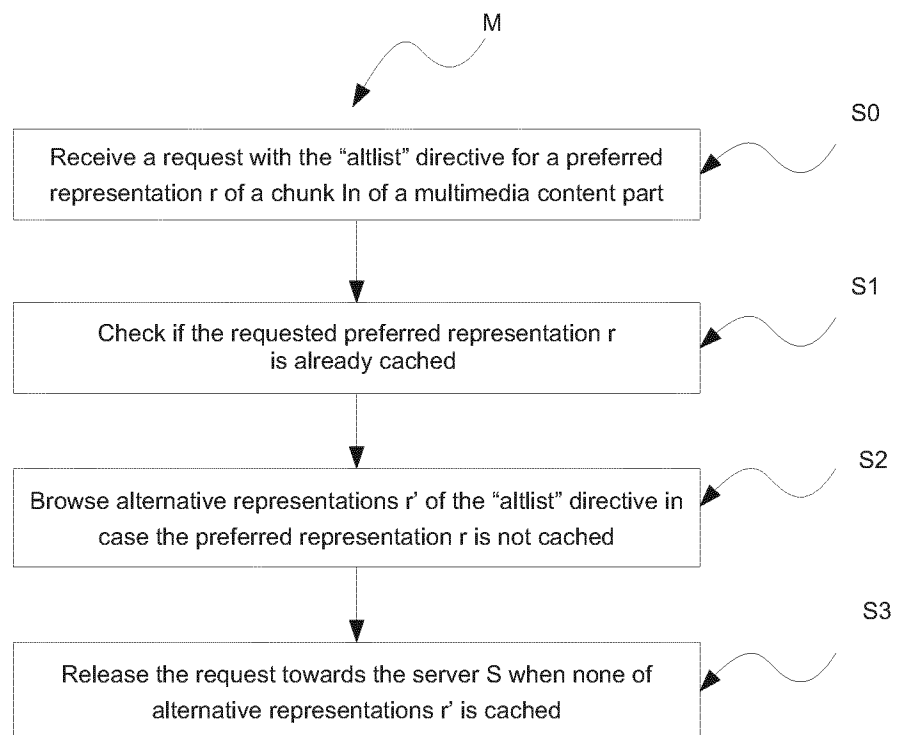
- 15 – an interface module (10) for receiving, from the client terminal (C), a request for a given representation of said content part belonging to a set of allowable representations selected among said available representations, said request further comprising a list of alternative representations of the set and additional information such that the interface module (10) returns the given representation or a listed alternative representation, if cached, or a response
20 message in case neither the given representation nor any of the listed alternative representations is cached;
- a controlling module (11) for checking if said given representation is stored;
- a browsing module (12) formed to browse the list of alternative representations, in case said given representation is not cached.

25

9. Cache according to claim 8, wherein the alternative representations are browsed in order of preference.

30 10. Cache according to claim 8 or 9, which is further configured for releasing said request when none of the alternative representations is cached.

**Figure 1****Figure 2**

**Figure 3****Figure 4**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/062214

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 2012/284371 A1 (BEGEN ALI C [CA] ET AL) 8 November 2012 (2012-11-08) abstract paragraph [0012] - paragraph [0040]; figures 1-5	1-10
A	----- EP 2 410 744 A1 (ALCATEL LUCENT [FR]) 25 January 2012 (2012-01-25) abstract paragraph [0009] - paragraph [0033]; figure 1 -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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