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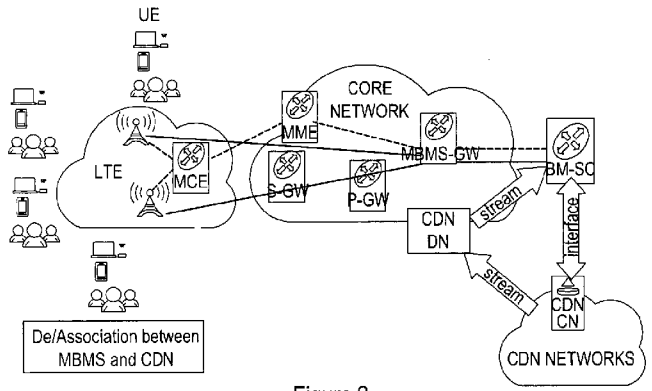

Figure 2

(57) Abstract: A method of delivering streaming media from a media source to a group of user terminals where those user terminals are located within a given cell of a Public Land Mobile Network. The method comprises delivering said streaming media from said media source to the user terminals via respective unicast sessions and, at said media source, monitoring the number and capabilities of user terminals within said group. The method further comprises, in dependence upon the number and capabilities of user terminals within said group, at said media source initiating a switch from said unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to a Broadcast-Multicast Service Centre, BM-SC, and, at said BM-SC, signalling to said user terminals to cause the user terminals to switch from receiving media via the respective unicast sessions to receiving media via said broadcast session, and commencing delivery of the streaming media via the MBMS broadcast session.A switch from MBMS multicast to unicast sessions is als provided for.

WO 2013/182247 A1

OPTIMISING CONTENT DELIVERY VIA UNICAST AND MULTICAST SERVICES OF A PUBLIC LAND MOBILE NETWORK

Technical field

The present invention relates to optimising content delivery via a Public Land Mobile Network (PLMN). It is applicable in particular to the case where the content is sourced from a Content Delivery Network (CDN).

Background

Data traffic over mobile networks is experiencing explosive growth, particularly due to the increased use of video streaming services including live video streaming services as well as video on demand (VoD). To optimise the network handling of streaming traffic, and hence improve the end user experience, content providers may make use of the services of a so-called Content Delivery Network (CDN). A CDN is implemented using a large number of servers distributed across the Internet. Special algorithms are used to deliver content to a particular end user, or groups of end users, in the most efficient manner. An example of a successful CDN operator is Akamai™ Technologies. Whilst certain of the algorithms used by the CDN may take into account externally visible properties of an access network being used by an end user to access the Internet, such as delivery latency and reliability. the CDN may not know or necessarily care about the details of the access network (although in some architectures the CDN may have a knowledge of access network properties and conditions). The CDN merely assumes that an appropriate “unicast bearer” can be established across the access network.

Considering the case where the access network is a Public Land Mobile Network (PLMN), streaming data may be delivered across the PLMN essentially as is illustrated in Figure 1 (assuming a 4G LTE network). Whilst the bandwidth available over the PLMN may be high, it is nonetheless finite and as such the illustrated Point to Point delivery of streaming content from the CDN to the user terminal (or UE according to 3GPP terminology) may not be efficient under certain circumstances.

Multimedia Broadcast/Multicast Service (MBMS) is a feature in 3GPP networks that enables the provision of services through multicast/broadcast transmission over PLMN networks, making use of both IP multicasting within the network and broadcast channels over the radio interface. This helps to save network resources when a large

number of users are interested in the same streaming service at the same time. Saving of resources is achieved because the same broadcast transmission can be received by several users, and the amount of network resources used is not dependent on the number of receivers, which is the case for unicast services. MBMS may be deployed in existing UMTS 3G networks as well as in current and future 4G LTE networks. It is currently anticipated that the MBMS broadcast mode will be the most widely implemented of the two modes.

Considering a 4G LTE network, MBMS introduces into the network the following functions (assuming that only the broadcast mode is available):

- The Broadcast Multicast Service Centre (BM-SC), which is a functional entity responsible for the authentication of users requesting access to an MBMS service, authorisation of external content providers, charging, and the overall configuration of data flows through the network.
- The MBMS Gateway (MBMS-GW) which is responsible for multi-casting packets from the BM-SC to LTE base stations (eNBs).
- The Multi-cell/Multicast Coordination Entity (MCE) which is responsible for coordinating resources and transmission parameters across all radio cells that belong to a Multicast-Broadcast Single Frequency Network (MBSFN) area. The MCE may be integrated directly into the eNB. A function of the MCE is to obtain from the eNBs details of the numbers of UEs receiving a given MBMS broadcast stream. Based upon this information, the MCE can decide to switch off an ongoing broadcast streaming service by switching off the associated broadcast radio channels. [NB. The MCE is not responsible for ensuring continued delivery of media to UEs within a given location after a broadcast channel in that area has been switched off. If the UE wishes to continue to receive media, then, if available, it may itself switch to a unicast session outside of the MBMS service.]

In a typical scenario, the PLMN operator will cooperate with a content provider to deliver a data flow using MBMS. The content provider transmits the data flow to the PLMN (BM-SC) for subsequent MBMS distribution. The PLMN may cache the data for playout as required. A user might obtain details of a particular MBMS “channel”, for example, from a web server. These details allow the user to “tune” into the broadcast radio channel and receive the content.

Where a content provider has an agreement with a CDN to provide its data to end users via the CDN, the CDN operator and not the content provider may have an agreement with the PLMN operator. As such, MBMS may be used to deliver the content from the CDN to end users via the PLMN infrastructure and the cellular radio interface. However, according to the existing solutions for LTE, the MBMS will be either on or off depending upon the agreement, regardless of the number of users receiving content at any given time. As long as the MBMS service is available within a given location, a broadcast radio channel will exist in that location. The only control that is available over resources is that provided by the MCE which may, for example, switch off the broadcast radio channel in its location if the number of UEs receiving the broadcast falls below some threshold.

Summary

According to a first aspect of the present invention there is provided apparatus configured to provide streaming media from a media source to a group of user terminals located within a given cell of a Public Land Mobile Network. The apparatus comprises a unicast session content delivery controller for causing the delivery of streaming media from said media source to each of the user terminals in said group of user terminals via respective unicast sessions. The apparatus further comprises a user terminal group monitor for monitoring the number and capabilities of the user terminals within said group, and initiating a switch from said unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to a Broadcast-Multicast Service Centre, BM-SC, in dependence upon the number and capabilities of the user terminals within said group.

The invention is applicable to various streaming services including, but not limited to, live streaming and video on demand (VoD).

Embodiments of the present invention may provide for a more efficient use of network and radio link resources by switching between an MBMS based broadcast and a CDN based unicast streaming service dynamically and flexibly based on the size of a user group within the same radio coverage area. More particularly, the coordination mechanism between the MBMS system and the CDN system makes it possible to ensure service continuity for UEs during switching between different media delivery approaches. A CDN control system based approach to triggering mobile network

bearer resource release, and re-establishment based on the coordination between CDN control system and the MBMS, may reduce the impact on UEs as well as being more reliable from a network operator point of view.

The apparatus may comprise an interface controller for enabling communication between the apparatus and a streaming media source, said unicast session content delivery controller being configured to use said interface controller to establish said unicast sessions between the streaming media source and said the user terminals. The user terminal group monitor may be configured such that said signalling to the BM-SC identifies said streaming media source or an alternative streaming media source from which the BM-SC can obtain streaming media to deliver over the MBMS broadcast session.

According to a second aspect of the present invention there is provided apparatus configured to operate as a Broadcast-Multicast Service Centre, BM-SC, to facilitate the provision of a Multimedia Broadcast/Multicast Service, MBMS, broadcast session across a Public Land Mobile Network. The apparatus comprises a first interface controller for exchanging data with a content delivery controller, the first interface controller being configured to receive from said content delivery controller an instruction, identifying a group of user terminals within a given cell of the Public Land Mobile Network, to establish a broadcast session for this group of users. The apparatus further comprises a broadcast session controller for controlling the establishment and termination of MBMS broadcast sessions, and for responding to receipt of said instruction by establishing an MBMS broadcast session for said group of users, and a second interface controller for receiving streaming media from a streaming media source, and for delivering that streaming media over said MBMS broadcast session.

The broadcast session controller may be configured to terminate said MBMS broadcast session if the number of user terminals in said group falls below some defined threshold and, via said first interface controller, to instruct said content delivery controller to deliver the streaming media via respective unicast sessions. The broadcast session controller may also, or alternatively, be configured to cause dedicated bearers, within the PLMN, associated with said user terminals to be terminated following establishment of the broadcast session. The broadcast session controller may be configured to cause dedicated bearers, within the PLMN, associated

with said user terminals to be established or re-established following termination of the broadcast session.

According to a third aspect of the present invention there is provided a user terminal configured for use with a Public Land Mobile Network, PLMN. The terminal comprises a media player for playing out streaming media, a receiver for receiving streaming media via the PLMN, and a controller for establishing a unicast session with a streaming media source, for configuring said receiver to receive streaming media via said unicast session, and for delivering the streaming media to said media player. The controller is further configured to receive an instruction from a Broadcast-Multicast Service Centre, BM-SC, within the PLMN, to begin receiving said streaming media via a Multimedia Broadcast/Multicast Service, MBMS, broadcast session and, in response, to configure said receiver to receive streaming media via said MBMS broadcast session and to deliver the streaming media to the media player.

The controller may be configured to receive an instruction from said BM-SC to begin receiving said streaming media via a unicast session and, in response, to configure said receiver to receive streaming media via the unicast session and to deliver the streaming media to the media player.

According to a fourth aspect of the present invention there is provided a method of delivering streaming media from a media source to a group of user terminals where those user terminals are located within a given cell of a Public Land Mobile Network. The method comprises delivering said streaming media from said media source to the user terminals via respective unicast sessions and, at said media source, monitoring the number and capabilities of user terminals within said group. The method further comprises, in dependence upon the number and capabilities of user terminals within said group, at said media source initiating a switch from said unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to a Broadcast-Multicast Service Centre, BM-SC, and, at said BM-SC, signalling to said user terminals to cause the user terminals to switch from receiving media via the respective unicast sessions to receiving media via said broadcast session, and commencing delivery of the streaming media via the MBMS broadcast session.

Other aspects of the present invention are set out in the appended claims.

Brief description of the drawings

Figure 1 illustrates schematically the delivery of streaming media from a Content Delivery Network to a group of user terminals, via a PLMN;

Figure 2 illustrates schematically an architecture, implemented in the context of LTE, which provides a new interface between a CDN control node and the BM-SC of an MBMS service;

Figure 3 illustrates schematically an alternative architecture according to which the CDN control node is provided at a local level, within the PLMN;

Figure 4 illustrates a procedure for switching from a CDN unicast mode to an MBMS broadcast mode, in the context of a 4G LTE network, comprising a first option (A) for delivering additional UE related information to a CDN CN;

Figure 5 illustrates a procedure for switching from a CDN unicast mode to an MBMS broadcast mode, in the context of a 4G LTE network comprising a second option (B) for delivering additional UE related information to a CDN CN;;

Figure 6 illustrates a procedure for switching from an MBMS broadcast mode to a CDN unicast mode, in the context of a 4G LTE network;

Figure 7 illustrates schematically a CDN Control Node suitable for use in the procedure of Figure 6;

Figure 8 illustrates schematically a BM-SC suitable for use in the procedure of Figure 6;

Figure 9 illustrates schematically a UE suitable for use in the procedure of Figure 6; and

Figure 10 is a flow diagram illustrating a method of efficiently switching from CDN multiple unicast sessions to broadcast MBMS sessions.

Detailed description

As has been discussed above, a Public Land Mobile Network (PLMN) may not always be able to use an MBMS broadcast service with optimal efficiency in order to deliver streaming content, provided to the PLMN via a Content Delivery Network (CDN), due to the fact that the number of UEs simultaneously receiving the same streaming content may be small or less than certain threshold at certain situation. This situation can be improved by implementing a new interface between the CDN control system (CDN CN) and the MBMS control system (BM-SC) to coordinate the streaming delivery mode over the PLMN. In particular, this interface allows support for determination of how and

when to switch between an MBMS broadcast mode and a CDN unicast mode. To ensure service continuation during a switch between different modes, a new function is introduced at the UE side. Based on the information from the network side, this new UE function is used to assist the UE to associate and switch between an MBMS broadcast session and a related CDN unicast session, at the appropriate time, thereby ensuring a continuous feed to the local media player.

Considering this proposal in more detail, the following key steps can be identified:

1. A streaming service request (DNS) from a mobile UE to the CDN CN function (collocated with a CDN DNS) is enriched with cell ID and PLMN ID information related to the UE, and possibly with P-GW ID / APN information and the UE's MBMS capability indication. This additional information can be added directly to the DNS request message by the UE, or can be added by a network device such as the P-GW upon interception of the message. A further option is for the UE to enrich an HTTP (streaming service request) message, exchanged with the CDN system, with this additional information.
2. The CDN CN selects a CDN DN to provide related unicast streaming content to the mobile UE. This content will be delivered to the UE over a downlink bearer established between the UE and the P-GW (establishment of this dedicated bearer is initiated by the UE).
3. The CDN CN stores the UE related information included in the request message, and counts the number of UEs with MBMS capability that are located in the same cell and that are requesting the same streaming media. In the event that the number of such UEs reaches a certain threshold, the CDN CN initiates a switch from CDN based unicast streaming to MBMS broadcast streaming. A CDN DN (the streaming media source) is selected to provide the related streaming content to the BM-SC.
4. The CDN CN then requests the BM-SC (identified to the CDN CN by the related PLMN/P-GW ID information) to start MBMS based streaming delivery by sending to it a message which identifies the streaming service (Channel ID) to be broadcast, the broadcast area (one or more cell IDs), and the assigned CDN DN address. The interface between the BM-SC and the CDN CN / CDN DN, may be provided by any suitable protocol, e.g. RADIUS/DIAMETER, LDAP, web, etc.
5. The BM-SC responds to receipt of this message by starting to receive related streaming content from the assigned CDN DN. During this process, the codec

approach is negotiated between the BM-SC and the CDN DN

6. The CDN DN stops unicast delivery of the same streaming content to the related UEs. However, related UE contexts may be maintained at the CDN DN to facilitate a possible switch back to unicast delivery.
7. The UE is informed by an MBMS service announcement about the association between the CDN based streaming service and the imminent MBMS based streaming service. [Before switching back to a CDN mode, the UE is similarly informed of the "disassociation"]. Based on this information from the network side, the UE is able to receive the streaming content from the right radio channel at the right time.
8. In the event that the MBMS determines that the related MBMS service should be stopped, based on a counting result obtained at the MCE, the MBMS initiates a switch back to CDN based streaming. The BM-SC instructs the CDN CN to recover the previous CDN based unicast streaming sessions for those UEs that are still receiving the ongoing streaming service.
9. Upon receiving the trigger from the MBMS system to recover the CDN based streaming service to UEs that are continuing to receive the streaming media, the CDN CN system initiates an internal process to recover the related streaming service between the specific CDN DN and those remaining UEs.

Figure 2 illustrates schematically an architecture, implemented in the context of LTE, which provides a new interface between the CDN CN and the BM-SC. Superimposed on the network architecture are the signalling plane connections (shown with broken lines) and the data plane connections (shown with solid lines). Figure 3 illustrates schematically an alternative implementation of the new approach. This moves the CDN CN to the local level, i.e. co-located with the CDN DN.

To make efficient use of radio resources and to ensure service continuation to UEs, in the event that a dedicated bearer (between the UE and the P-GW) is established to carry the unicast streaming service, this dedicated bearer should be released when the MBMS broadcast bearer is established. Releasing this bearer will result in the associated radio resources being released. On the other hand, when a decision is made to switch back from MBMS streaming to CDN streaming, specific dedicated bearers (and associated radio resources) must be established before the MBMS based streaming traffic is released. The following procedure may be employed for this purpose:

I. Once the CDN CN system knows that the CDN based streaming service will be delivered to a UE by MBMS mode, it informs the Policy and Charging Rules Function (PCRF) – a function specified for the 3GPP PCC architecture - serving the relevant UEs that CDN based streaming service to these UEs is being stopped. The PCRF initiates the process to release the associated dedicated bearers – either terminating or suspending the bearers - carrying the CDN streaming service (it does this via the Gx interface with the P-GW). The UE contexts may be maintained at the CDN CN to facilitate the bearer re-establishment process in case a switch from MBMS to CDN mode is subsequently made.

II. Once the CDN CN system knows that the MBMS based streaming service will be stopped and that CDN based streaming will be used to serve the UEs, it informs the PCRF serving these UEs that the CDN based streaming service will start. The PCRF initiates a specific process, again using the Gx interface with the P-GW, to re-establish dedicated bearers to carry the CDN based streaming service.

Figure 4 illustrates in more detail the process for switching between MBMS multicast mode and a CDN unicast mode, taking as an example a 4G LTE network. It includes a first alternative, Option A, for delivering additional information to the CDN CN. In more detail, Option A involves piggybacking additional information on the existing DNS request message. A new function is introduced at the UE and which is configured to enrich the DNS message with additional information as set out above. Following establishment of a default bearer, the UE sends the enriched DNS request message to the DNS server in order to determine the IP address of the content/service server. In the case that the required service is provided by a CDN network, the DNS server forwards the message to the DNS server of the CDN network. Upon receipt of the DNS request message, the CDN control system stores the UE related information.

An alternative (within the scope of Option A) relies upon the operation of some Deep Packet Inspection (DPI) function to allow the P-GW to detect the DNS request from the mobile UE. In case the UE can't enrich the DNS request message with the necessary information, the P-GW/GGSN enriches the DNS request message with the UE related information, as well as possibly including the P-GW ID to assist the CDN system in finding the appropriate BM-SC. The P-GW/GGSN could identify a DNS requiring enrichment based on the information included in the DNS message, for example by

identifying a DNS request related to a certain site or certain content that is to be served by a CDN provider.

Following delivery of the additional information, and assuming establishment of the CDN unicast streaming session for the various UEs, the CDN control system counts the number of UEs located within the same cell, watching the same live streaming content, and with MBMS capability. In case the number exceeds some predefined threshold (e.g. five), the CDN control system initiates the transition from the CDN based unicast streaming service to the MBMS based broadcast streaming service

The CDN control system sends a message, such as an MBMS service request, to the MB-SC (identified using the PLMN information) to trigger the MBMS service. The message should indicate the broadcast area (indicated by a list of cell ID), streaming content (may be indicated by channel ID) to be broadcast, and the CDN DN ID for the BM-SC to retrieve related streaming content. Related APN information may be provided to enable the BM-SC to identify the correct MBMS-GW.

Upon reception of this message from the CDN control system, the BM-SC completes the related process. It then initiates the process to retrieve related streaming content from the indicated CDN DN. Before initiating the actual streaming service, the BM-SC initiates a service announcement process to the related UEs. In particular, the service announcement indicates that the coming MBMS based streaming service will replace an ongoing unicast based streaming service.

When the required resource is ready for the MBMS, the BM-SC replies to the CDN control system with a response message (possibly indicating the accepted broadcast area - it is possible that a broadcast service is not available in a certain area at a certain moment). Based on the response from the BM-SC, the CDN control system determines whether to terminate or suspend the unicast streaming service to certain UEs for which MBMS is available (other UEs without MBMS service will continue to receive the CDN streaming service). Meanwhile, the CDN control system informs the PCRF (e.g. via an Rx interface) that the CDN based streaming service will be terminated/suspended for certain UEs. In response, the PCRF initiates the process to release related dedicated bearers for the appropriate UEs. Related UE context may be maintained at the CDN CN to facilitate related bearer re-establishment in the event that MBMS based streaming is subsequently switched off. The CDN DN terminates or

suspends the related unicast streaming services as directed by the CDN control system. Related UE contexts may be maintained for some time to allow the efficient recovery of related CDN streaming services later, if required.

Upon reception of the MBMS service announcement message, a UE switches from the dedicated bearer to the MBMS broadcast bearer (and from the associated dedicated downlink radio channel to the broadcast radio channel) in order to receive the required streaming content. A new function may be provided within the UE to perform this procedure, e.g. located between the media layer and the PDCP layer (which is responsible for handling the radio bearers). The new function ensures that the correct content is fed to the media player from the correct bearer.

Figure 5 illustrates again a process for switching between MBMS multicast mode and a CDN unicast mode, taking as an example a 4G LTE network, but illustrating an alternative procedure for delivering additional information to the CDN CN, referred to here as Option B. This involves using a new custom protocol message to exchange additional information between the UE and the CDN control system. Following establishment of the default bearer, the UE sends out the enriched CDN service request message to the DNS server in order to determine the IP address of the content/service server. The P-GW routes the IP packets carrying the CDN service request message (proprietary protocol) to the CDN CN system. In the case that the required service is provided by a CDN network, the DNS server forwards the message to the DNS server of the CDN network. Upon receipt of the CDN service request message, the CDN control system stores the UE related information as input to decide whether MBMS based broadcast delivery should be initiated or not.

As has already been discussed above, if the number of UEs receiving an MBMS broadcast streaming service falls below some threshold level, it may be efficient to switch back from the MBMS mode to the CDN unicast mode. A mechanism for achieving this switch may be as follows - see Figure 6. [Of course, a similar mechanism may be used to perform a switch from MBMS mode to the CDN unicast mode when no previous unicast modes existed.]

Based on a counting result, the MCE may decide to terminate an ongoing MBMS streaming service. The MCE informs the BM-SC of the broadcast area in which the service is to be terminated (i.e. in which the broadcast radio channel is to be switched

off). It also informs the BM-SC those UEs presently within that broadcast area which should continue to receive the streaming content. Based on this information, the BM-SC initiates the switch from MBMS based streaming to CDN based streaming.

The BM-SC sends a message to the CDN control system to inform it that the broadcast based streaming service will be stopped to some UEs, and CDN based unicast streaming should proceed to ensure service continuation to those UEs. The CDN CN may reply to the BM-SC with a confirmation message. The CDN CN informs the PCRF that certain CDN based streaming services will be recovered for certain UEs, and the PCRF acknowledges receipt of this instruction to the CDN CN. Based on the trigger from the CDN CN, the PCRF initiates the process to re-establish/recover related dedicated bearer resources for the UEs.

The CDN CN instructs the related CDN DN to start to recover the related streaming services to the required UEs. Based on the request from the CDN CN, the CDN DN starts/recovers the related streaming services to the indicated UEs. Meanwhile, the BM-SC provides another service announcement to inform the relevant UEs that a specific ongoing MBMS based streaming service will be replaced by a CDN based unicast streaming service.

Upon receipt of the MBMS service announcement message, a UE will disassociate the MBMS service with the ongoing streaming service. After the dedicated bearer is re-established for the streaming service, the UE switches from the broadcast bearer to the dedicated bearer (and switches from the broadcast radio channel to a dedicated downlink channel) and receives the streaming content substantially without disruption.

Figure 7 illustrates schematically a CDN CN such as might be used to implement the procedure described above. The CDN CN 1 comprises a unicast session content delivery controller 2 for causing the delivery of streaming media from a media source (CDN) to user terminals via respective unicast sessions. A user terminal group monitor 3 is provided for monitoring the number and capabilities of user terminals within a group (within a common location). The user terminal group monitor 3 is able to initiate a switch from the unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to the Broadcast-Multicast Service Centre, BM-SC, in dependence upon the number and capabilities of user terminals within the group. The CDN CN further comprises interfaces and interface controllers 20, 21 that

facilitate communication with the CDN DN and BM-SC.

Figure 8 illustrates schematically a BM-SC 4 such as might be used to implement the procedure described above. It comprises a first interface controller 5 for exchanging data with a content delivery controller (CDN CN), the controller being configured to receive from the content delivery controller an instruction, identifying a group of user terminals within a given cell of the PLMN, to establish a broadcast session for this group of users. It further comprises a broadcast session controller 6 for controlling the establishment and termination of MBMS broadcast sessions, and for responding to receipt of the instruction by establishing broadcast session for the group of users. A second interface controller 7 is provided for receiving streaming media from a streaming media source, and for delivering that media over the MBMS broadcast session.

Figure 9 illustrates schematically a user terminal 9 configured for use with a Public Land Mobile Network, PLMN, and being configured to operate according to the procedures described above. The terminal 9 comprises a media player 10 for playing out streaming media. This could be for example a video application (e.g. implemented into a web browser). The terminal 9 further comprises a receiver 11 for receiving streaming media via the PLMN. This receiver will comprise conventional components for connecting to the radio interface. A controller 12 is provided for establishing a unicast session with a streaming media source, for configuring the receiver 11 to receive streaming media via the unicast session, and for delivering the streaming media to the media player 10. The controller 12 is further configured to receive an instruction from a Broadcast-Multicast Service Centre, BM-SC, within the PLMN, to begin receiving the streaming media via a Multimedia Broadcast/Multicast Service, MBMS, broadcast session. In response to this instruction, the controller 12 configures the receiver 11 to receive streaming media via the MBMS broadcast session and to deliver the streaming media to the media player 10.

It is noted that the apparatus illustrated in Figures 7 to 9 will be implemented using various hardware components, including processors and memories, as well as appropriate software.

Referring now to Figure 10, this presents a flow diagram of the general procedure for switching from CDN unicast sessions to an MBMS broadcast session. The flow

assumes that multiple unicast streaming sessions are established at step S1, between the CDN and a group of UEs. At step S2, the streaming media is delivered to these UEs via the respective unicast sessions. At step S3, the CDN CN within the CDN monitors the number of ongoing unicast sessions and the properties of the UEs involved (including MBMS capabilities and UE locations). At step S4 the CDN CN determines that a sufficient number of MBMS capable UEs are present within a given location (and are already receiving unicast sessions). As a result, at step S5, the CDN CN signals to the BM-SC that a switch to an MBMS session should be made. At step S6, the BM-SC notifies the UEs of the switching requirements, establishes an MBMS broadcast session, and commences the streaming of media over that broadcast session.

It will be appreciated by the person of skill in the art that various modifications may be made to the above described embodiments without departing from the scope of the present invention. For example, whilst the discussion above has presented the CDN CN as part of a network that is outside of the PLMN operator domain, this node may be within the PLMN operator domain. For example, the CDN CN may be collocated with the GGSN of a 3G network, or with the P-GW of an LTE network. Content is cached at the GGSN for delivery to end users via unicast or MBMS broadcast services.

CLAIMS:

1. Apparatus configured to provide streaming media from a media source to a group of user terminals located within a given cell of a Public Land Mobile Network, the apparatus comprising:

a unicast session content delivery controller (2) for causing the delivery of streaming media from said media source to each of the user terminals in said group of user terminals via respective unicast sessions; and

a user terminal group monitor (3) for

monitoring the number and capabilities of the user terminals within said group, and

initiating a switch from said unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to a Broadcast-Multicast Service Centre, BM-SC, in dependence upon the number and capabilities of the user terminals within said group.

2. Apparatus according to claim 1, the apparatus comprising an interface controller (20) for enabling communication between the apparatus and a streaming media source, said unicast session content delivery controller (2) being configured to use said interface controller (20) to establish said unicast sessions between the streaming media source and said the user terminals.

3. Apparatus according to claim 2, said user terminal group monitor (3) being configured such that said signalling to the BM-SC identifies said streaming media source or an alternative streaming media source from which the BM-SC can obtain streaming media to deliver over the MBMS broadcast session.

4. Apparatus according to any one of the preceding claims, said unicast session content delivery controller (2) being configured to terminate said unicast sessions following establishment of the MBMS broadcast session.

5. Apparatus configured to operate as a Broadcast-Multicast Service Centre, BM-SC, to facilitate the provision of a Multimedia Broadcast/Multicast Service, MBMS, broadcast session across a Public Land Mobile Network, the apparatus comprising:

a first interface controller (5) for exchanging data with a content delivery controller, the first interface controller (5) being configured to receive from said

content delivery controller an instruction, identifying a group of user terminals within a given cell of the Public Land Mobile Network, to establish a broadcast session for this group of users;

a broadcast session controller (6) for controlling the establishment and termination of MBMS broadcast sessions, and for responding to receipt of said instruction by establishing an MBMS broadcast session for said group of users; and

a second interface controller (7) for receiving streaming media from a streaming media source, and for delivering that streaming media over said MBMS broadcast session.

6. Apparatus according to claim 5, said broadcast session controller (6) being configured to terminate said MBMS broadcast session if the number of user terminals in said group falls below some defined threshold and, via said first interface controller (5), to instruct said content delivery controller to deliver the streaming media via respective unicast sessions.

7. Apparatus according to claim 5 or 6, wherein said broadcast session controller (6) is configured to cause dedicated bearers, within the PLMN, associated with said user terminals to be terminated following establishment of the broadcast session.

8. Apparatus according to claim 7 when appended to claim 6, said broadcast session controller (6) being configured to cause dedicated bearers, within the PLMN, associated with said user terminals to be established or re-established following termination of the broadcast session.

9. A user terminal configured for use with a Public Land Mobile Network, PLMN, the terminal comprising:

a media player (19) for playing out streaming media:

a receiver (11) for receiving streaming media via the PLMN;

a controller (12) for establishing a unicast session with a streaming media source, for configuring said receiver (11) to receive streaming media via said unicast session, and for delivering the streaming media to said media player (19),

the controller (12) being further configured to receive an instruction from a Broadcast-Multicast Service Centre, BM-SC, within the PLMN, to begin

receiving said streaming media via a Multimedia Broadcast/Multicast Service, MBMS, broadcast session and, in response, to configure said receiver (11) to receive streaming media via said MBMS broadcast session and to deliver the streaming media to the media player (10).

10. A user terminal according to claim 9, said controller (12) being configured to receive an instruction from said BM-SC to begin receiving said streaming media via a unicast session and, in response, to configure said receiver (11) to receive streaming media via the unicast session and to deliver the streaming media to the media player (12).

11. A method of delivering streaming media from a media source to a group of user terminals where those user terminals are located within a given cell of a Public Land Mobile Network, the method comprising:

delivering said streaming media from said media source to the user terminals via respective unicast sessions (S2);

at said media source, monitoring the number and capabilities of user terminals within said group (S3);

in dependence upon the number and capabilities of user terminals within said group (S4), at said media source initiating a switch from said unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to a Broadcast-Multicast Service Centre, BM-SC (S5); and

at said BM-SC, signalling to said user terminals to cause the user terminals to switch from receiving media via the respective unicast sessions to receiving media via said broadcast session, and commencing delivery of the streaming media via the MBMS broadcast session (S6).

12. A method according to claim 11, wherein said media source is a Content Delivery Network, CDN, comprising a CDN Control Node and a CDN Delivery Node, said step of initiating a switch from said unicast sessions to the Multimedia Broadcast/Multicast Service, MBMS, broadcast session being carried out at said CDN Control Node.

13. A method according to claim 11 or 12 and comprising, following commencement of said MBMS broadcast session, at said BM-SC making a determination that the session should be terminated and unicast sessions should be

commenced or recommenced and, in response, terminating the MBMS broadcast session and notifying the media source to resume unicast sessions.

14. A method according to any one of claims 11 to 12 and comprising, on commencement of said MBMS session, causing a packet gateway within the PLMN to terminate or suspend dedicated bearers across the PLMN associated with said user terminals.

15. A method according to claim 14 when appended to claim 13 and comprising, upon termination of said MBMS session, causing said packet gateway to establish or re-establish said dedicated bearers.

16. A method of providing streaming media from a media source to a group of user terminals located within a given cell of a Public Land Mobile Network, the method comprising:

delivering streaming media from said media source to each of the user terminals in said group of user terminals via respective unicast sessions;

monitoring the number and capabilities of the user terminals within said group; and

initiating a switch from said unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to a Broadcast-Multicast Service Centre, BM-SC, in dependence upon the number and capabilities of the user terminals within said group.

17. A method of facilitating the provision of a Multimedia Broadcast/Multicast Service, MBMS, broadcast session across a Public Land Mobile Network, the method comprising:

receiving from a content delivery controller an instruction, identifying a group of user terminals within a given cell of the Public Land Mobile Network, to establish a broadcast session for this group of users;

responding to receipt of said instruction by establishing an MBMS broadcast session for said group of users; and

receiving streaming media from a streaming media source, and delivering that streaming media over said MBMS broadcast session.

18. A method of operating a user terminal configured for use with a Public Land

Mobile Network, PLMN, the method comprising:

receiving streaming media via the PLMN;

establishing a unicast session with a streaming media source, receiving streaming media via said unicast session, and delivering the streaming media to said media player,

receiving an instruction from a Broadcast-Multicast Service Centre, BM-SC, within the PLMN, to begin receiving said streaming media via a Multimedia Broadcast/Multicast Service, MBMS, broadcast session and, in response, to receiving streaming media via said MBMS broadcast session and delivering the streaming media to the media player.

19. A computer program comprising a computer-readable medium bearing computer program code embodied therein for use with a computer, the computer program code being arranged to provide streaming media from a media source to a group of user terminals located within a given cell of a Public Land Mobile Network, the computer program code comprising:

code for delivering streaming media from said media source to each of the user terminals in said group of user terminals via respective unicast sessions;

code for monitoring the number and capabilities of the user terminals within said group; and

code for initiating a switch from said unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to a Broadcast-Multicast Service Centre, BM-SC, in dependence upon the number and capabilities of the user terminals within said group.

20. A computer program comprising a computer-readable medium bearing computer program code embodied therein for use with a computer, the computer program code being arranged to facilitate the provision of a Multimedia Broadcast/Multicast Service, MBMS, broadcast session across a Public Land Mobile Network, the computer program code comprising:

code for receiving from a content delivery controller an instruction, identifying a group of user terminals within a given cell of the Public Land Mobile Network, to establish a broadcast session for this group of users;

code for responding to receipt of said instruction by establishing an MBMS broadcast session for said group of users; and

code for receiving streaming media from a streaming media source, and

delivering that streaming media over said MBMS broadcast session.

21. A computer program comprising a computer-readable medium bearing computer program code embodied therein for use with a computer, the computer program code being arranged to operate a user terminal configured for use with a Public Land Mobile Network, PLMN, the computer program code comprising:

code for receiving streaming media via the PLMN;

code for establishing a unicast session with a streaming media source, receiving streaming media via said unicast session, and for delivering the streaming media to said media player,

code for receiving an instruction from a Broadcast-Multicast Service Centre, BM-SC, within the PLMN, for receiving said streaming media via a Multimedia Broadcast/Multicast Service, MBMS, broadcast session and, in response, for receiving streaming media via said MBMS broadcast session and delivering the streaming media to the media player.

22. A computer-readable medium encoded with instructions that, when executed by a computer in a system providing streaming media from a media source to a group of user terminals located within a given cell of a Public Land Mobile Network, perform:

delivering streaming media from said media source to each of the user terminals in said group of user terminals via respective unicast sessions;

monitoring the number and capabilities of the user terminals within said group; and

initiating a switch from said unicast sessions to a Multimedia Broadcast/Multicast Service, MBMS, broadcast session by signalling to a Broadcast-Multicast Service Centre, BM-SC, in dependence upon the number and capabilities of the user terminals within said group.

23. A computer-readable medium encoded with instructions that, when executed by a computer in a system facilitating the provision of a Multimedia Broadcast/Multicast Service, MBMS, broadcast session across a Public Land Mobile Network, perform:

receiving from a content delivery controller an instruction, identifying a group of user terminals within a given cell of the Public Land Mobile Network, to establish a broadcast session for this group of users;

responding to receipt of said instruction by establishing an MBMS broadcast session for said group of users; and

receiving streaming media from a streaming media source, and delivering that streaming media over said MBMS broadcast session.

24. A computer-readable medium encoded with instructions that, when executed by a computer in a system comprising a user terminal configured for use with a Public Land Mobile Network, PLMN, perform:

receiving streaming media via the PLMN;

establishing a unicast session with a streaming media source, receiving streaming media via said unicast session, and delivering the streaming media to said media player,

receiving an instruction from a Broadcast-Multicast Service Centre, BM-SC, within the PLMN to begin receiving said streaming media via a Multimedia Broadcast/Multicast Service, MBMS, broadcast session and, in response, receiving streaming media via said MBMS broadcast session and delivering the streaming media to the media player.

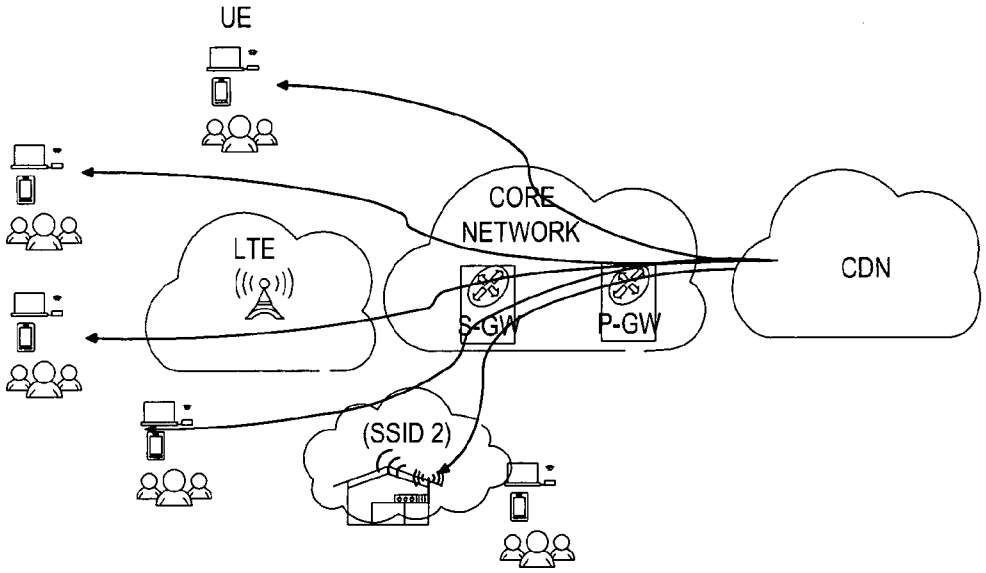

Figure 1

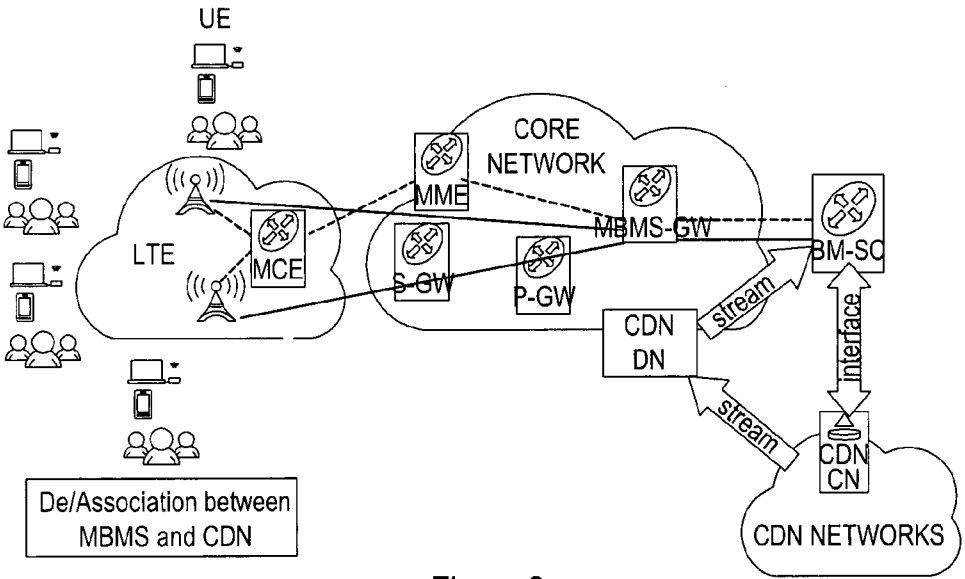

Figure 2

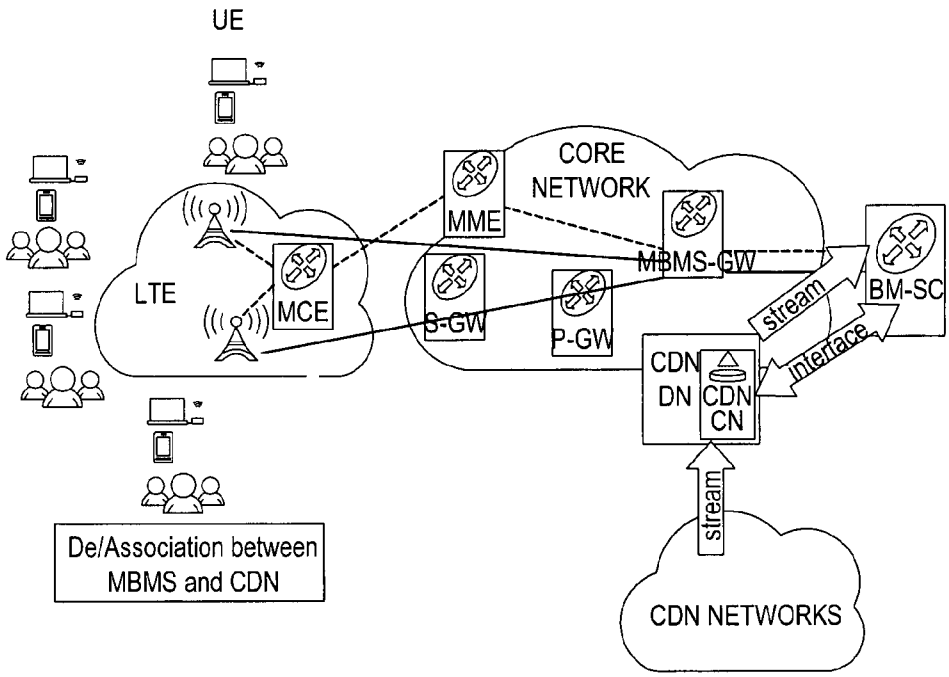
UE
CORE
NETWORK
MME
MBMS-GW
BM-SC
LTE
MCE
S-GW
P-GW
stream
interface
CDN
DN
CDN
CN
stream
De/Association between
MBMS and CDN
CDN NETWORKS

Figure 3

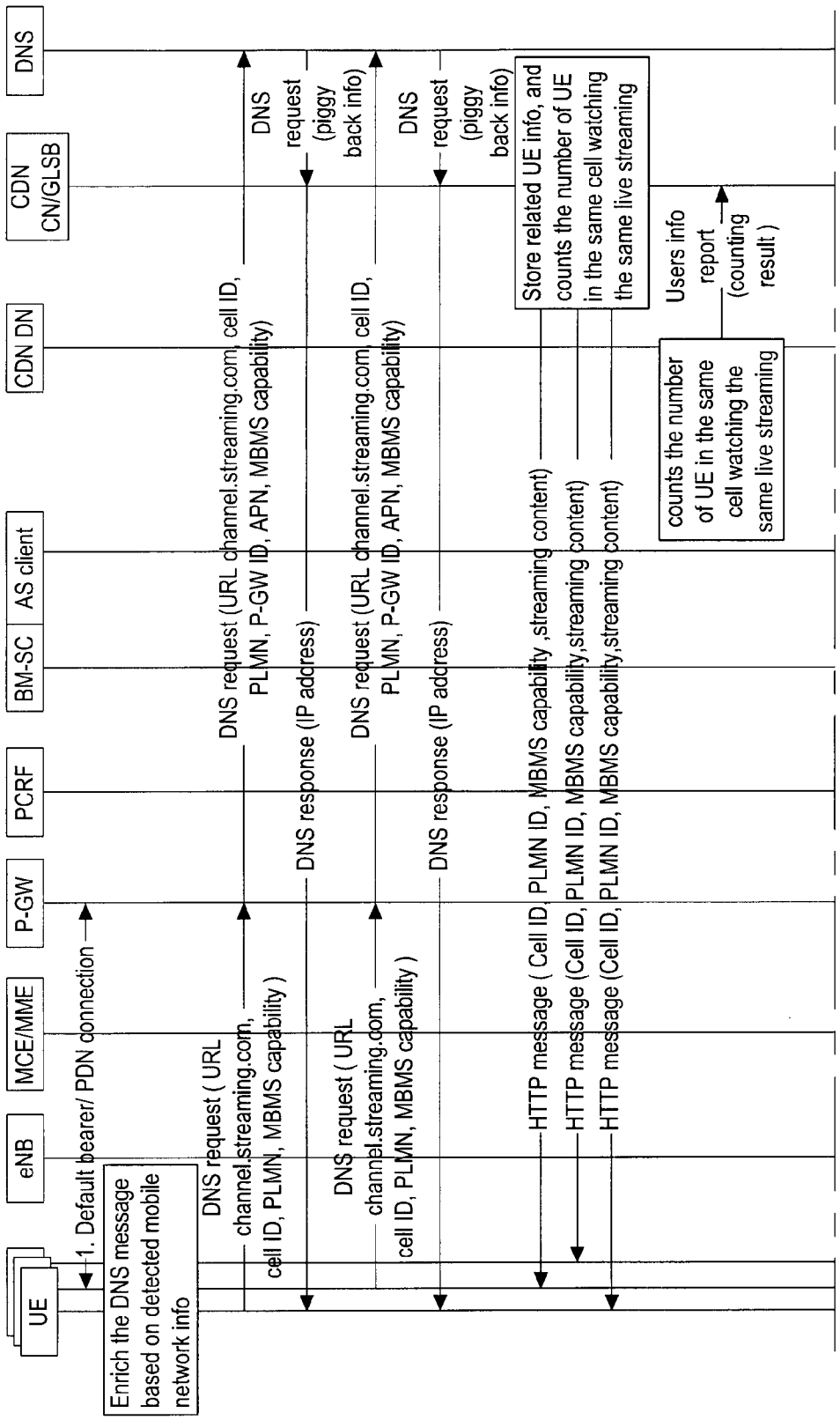
UE
eNB
MCE/MME
P-GW
PCRF
BM-SC
AS client
CDN DN
CDN CN/GLSB
DNS
1. Default bearer/ PDN connection
Enrich the DNS message based on detected mobile network info
DNS request (URL channel.streaming.com, cell ID, PLMN, MBMS capability)
DNS request (URL channel.streaming.com, cell ID, PLMN, P-GW ID, APN, MBMS capability)
DNS request (piggy back info)
DNS response (IP address)
DNS request (URL channel.streaming.com, cell ID, PLMN, MBMS capability)
DNS request (URL channel.streaming.com, cell ID, PLMN, P-GW ID, APN, MBMS capability)
DNS request (piggy back info)
DNS response (IP address)
HTTP message (Cell ID, PLMN ID, MBMS capability ,streaming content)
HTTP message (Cell ID, PLMN ID, MBMS capability,streaming content)
HTTP message (Cell ID, PLMN ID, MBMS capability,streaming content)
Store related UE info, and counts the number of UE in the same cell watching the same live streaming
counts the number of UE in the same cell watching the same live streaming
Users info report (counting result)

Figure 4

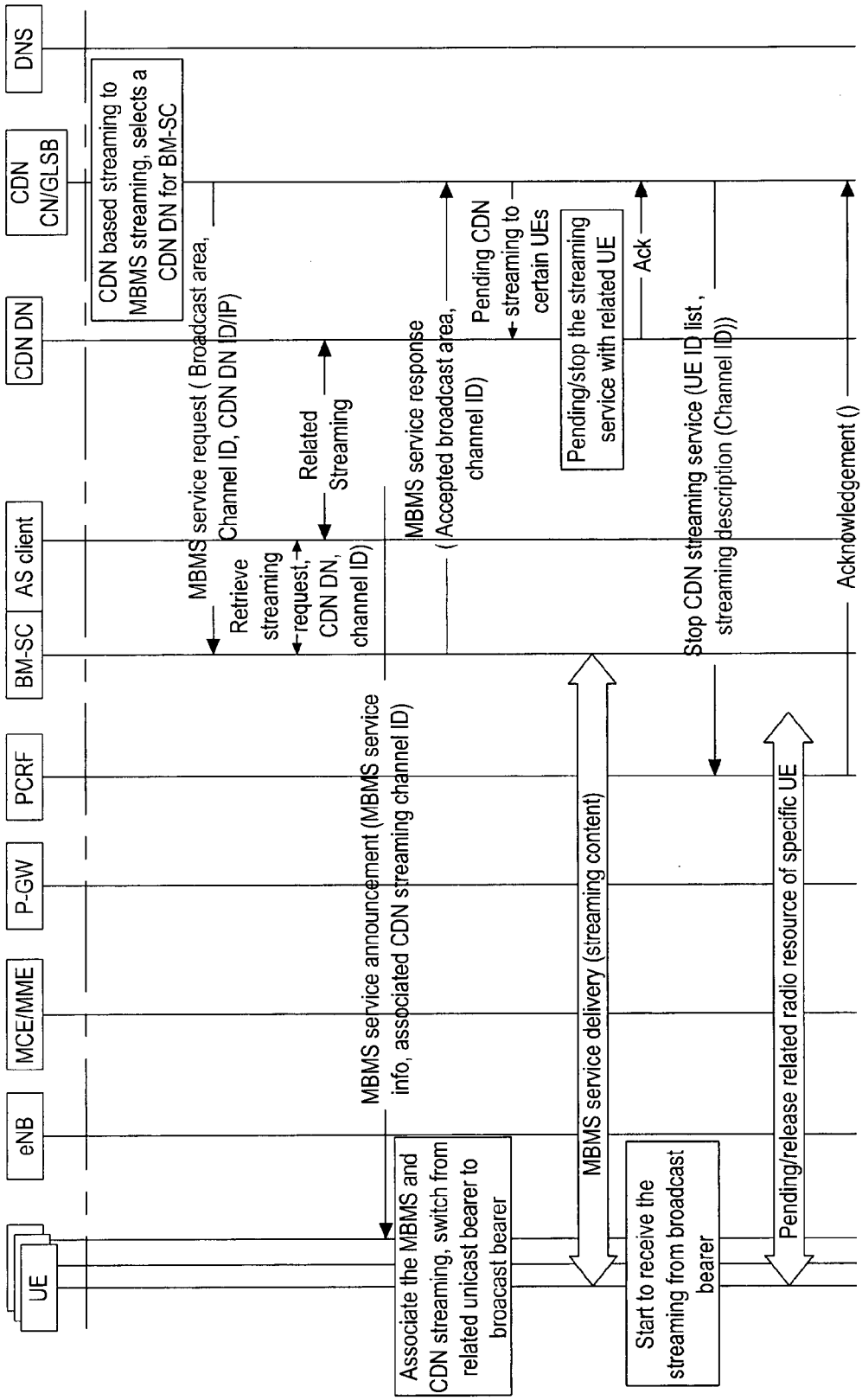

Figure 4 (Continued)

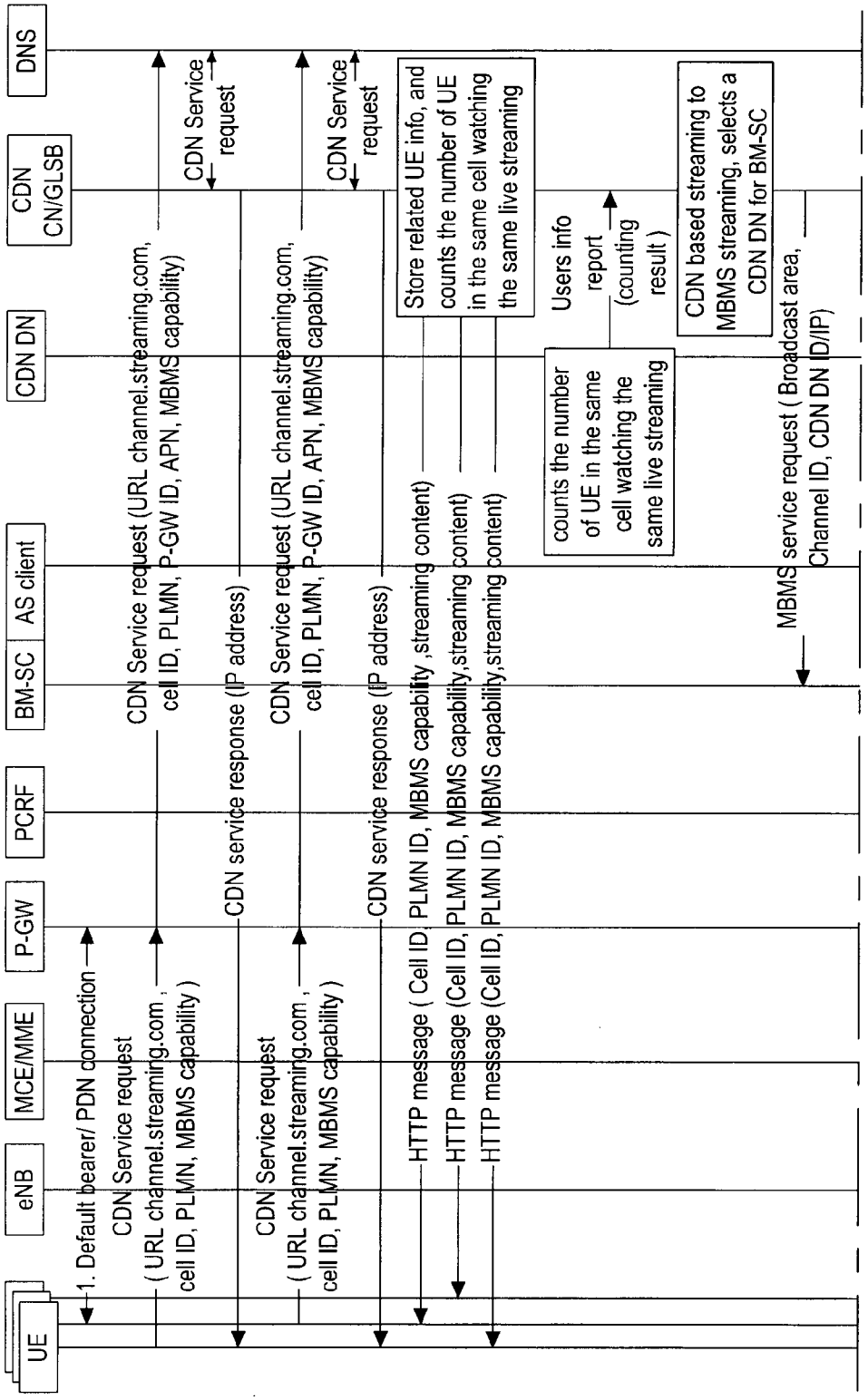
UE
eNB
MCE/MME
P-GW
PCRF
BM-SC
AS client
CDN DN
CDN CN/GLSB
DNS
1. Default bearer/ PDN connection
CDN Service request (URL channel.streaming.com , cell ID, PLMN, MBMS capability)
CDN Service request (URL channel.streaming.com, cell ID, PLMN, P-GW ID, APN, MBMS capability)
CDN Service request
CDN service response (IP address)
CDN Service request (URL channel.streaming.com , cell ID, PLMN, MBMS capability)
CDN Service request (URL channel.streaming.com, cell ID, PLMN, P-GW ID, APN, MBMS capability)
CDN Service request
CDN service response (IP address)
HTTP message (Cell ID, PLMN ID, MBMS capability ,streaming content)
HTTP message (Cell ID, PLMN ID, MBMS capability,streaming content)
HTTP message (Cell ID, PLMN ID, MBMS capability,streaming content)
Store related UE info, and counts the number of UE in the same cell watching the same live streaming
counts the number of UE in the same cell watching the same live streaming
Users info report (counting result)
CDN based streaming to MBMS streaming, selects a CDN DN for BM-SC
MBMS service request (Broadcast area, Channel ID, CDN DN ID/IP)

Figure 5

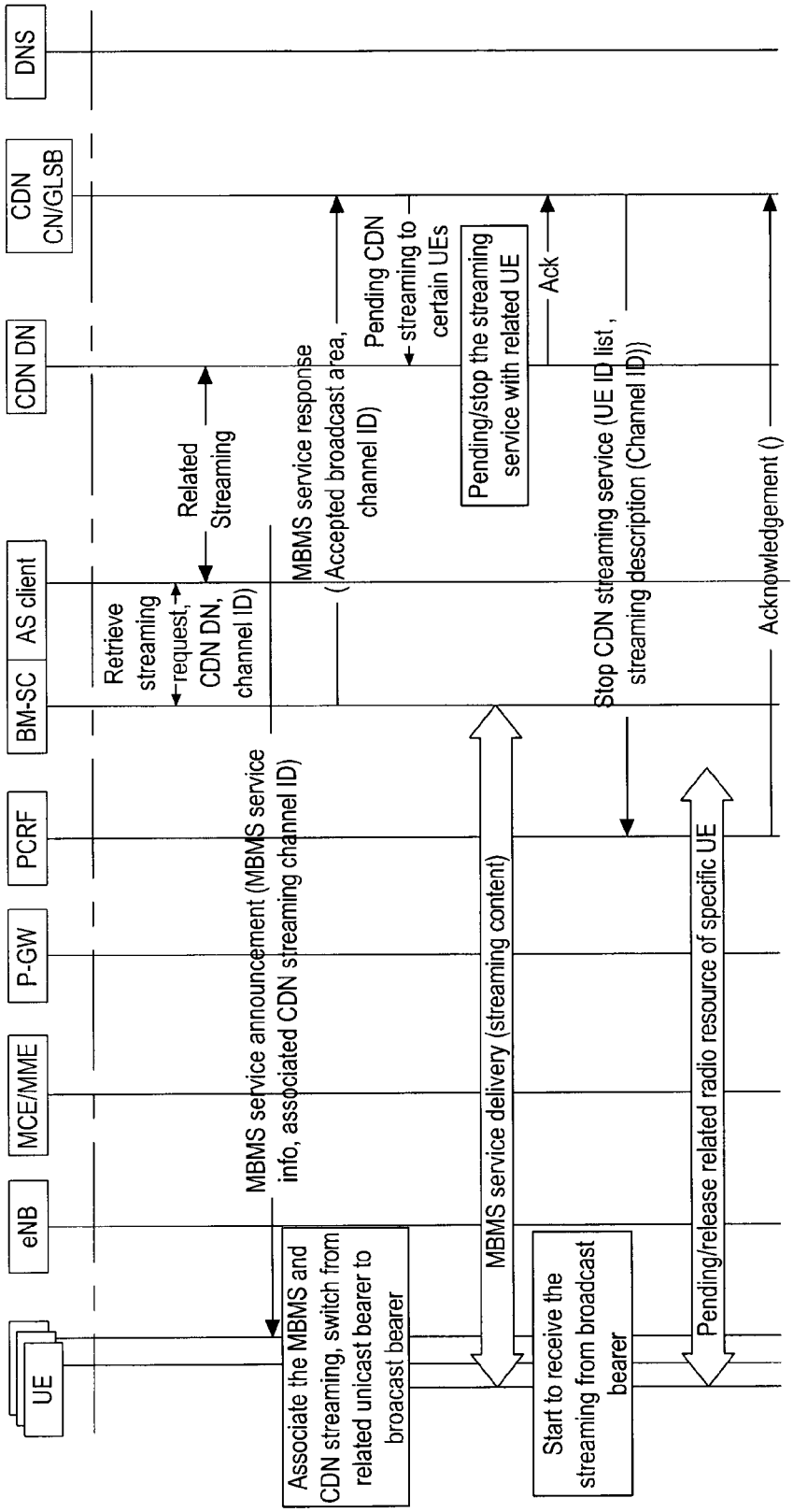

Figure 5 (Continued)

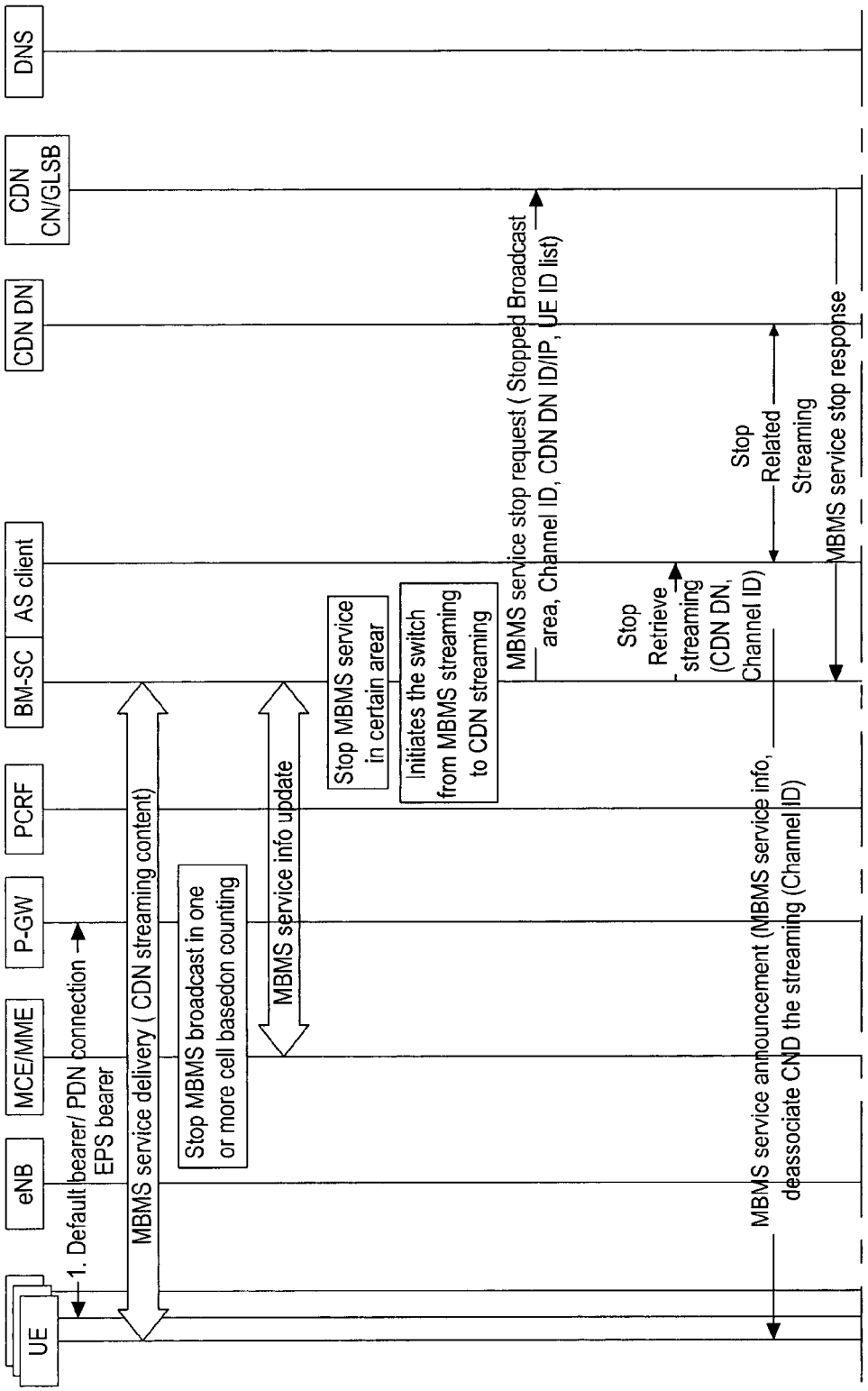
DNS
CDN CN/GLSB
CDN DN
BM-SC AS client
PCRF
P-GW
MCE/MME
eNB
UE
1. Default bearer/ PDN connection → EPS bearer
MBMS service delivery (CDN streaming content)
Stop MBMS broadcast in one or more cell basedon counting
MBMS service info update
Stop MBMS service in certain arear
Initiates the switch from MBMS streaming to CDN streaming
MBMS service stop request (Stopped Broadcast area, Channel ID, CDN DN ID/IP, UE ID list)
Stop Retrieve streaming (CDN DN, Channel ID)
Stop Related Streaming
MBMS service stop response
MBMS service announcement (MBMS service info, deassociate CND the streaming (Channel ID)

Figure 6

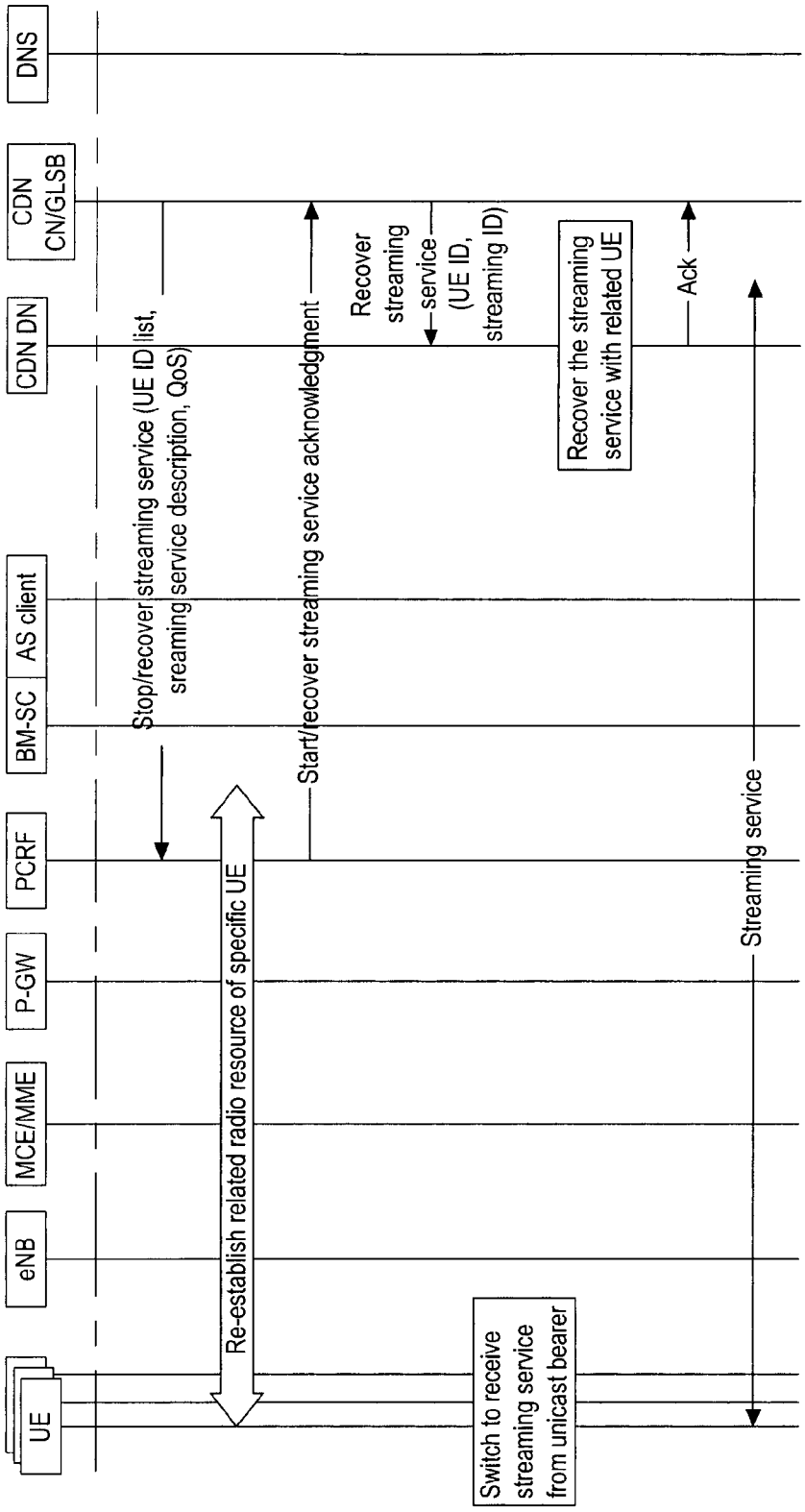

Figure 6 (Continued)

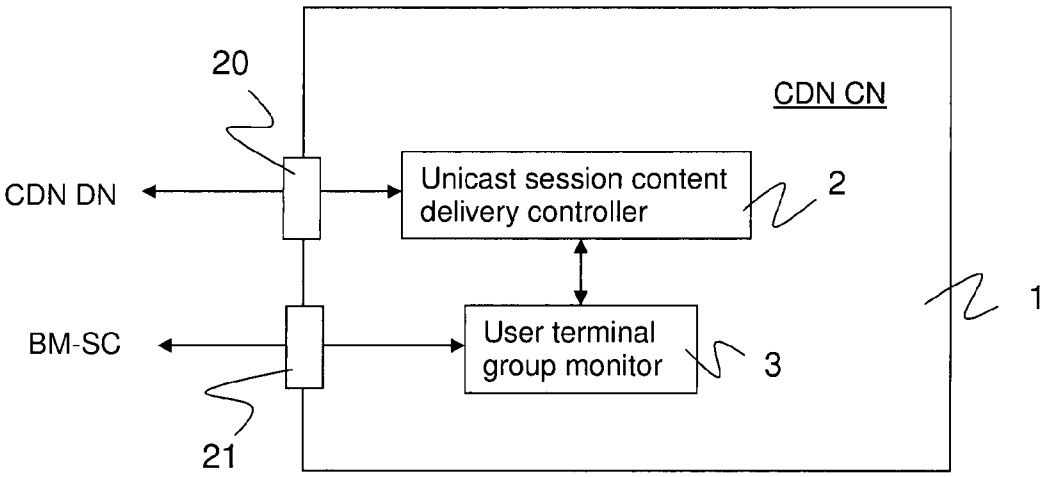

Figure 7

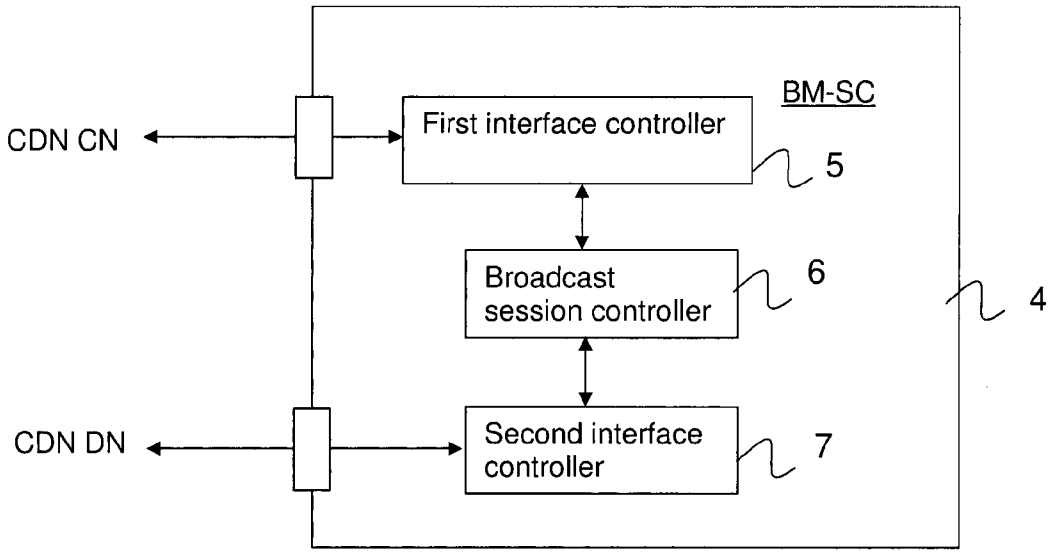

Figure 8

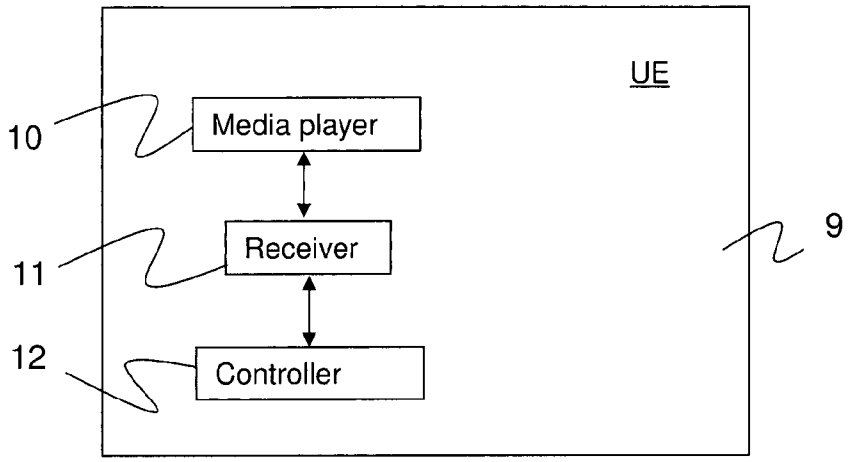

Figure 9

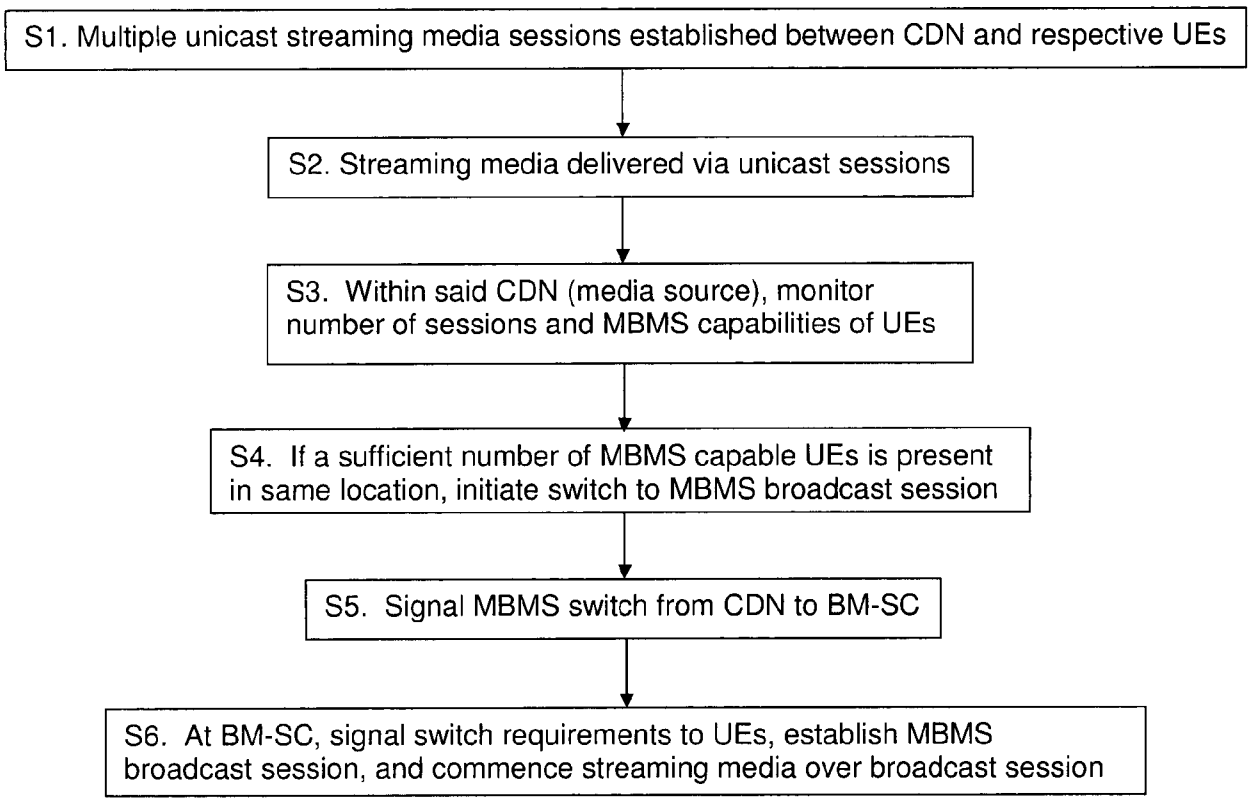

Figure 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/060858

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/00
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)
H04W

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, COMPENDEX, INSPEC, 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 2007/177592 A1 (MOONEY CHRISTOPHER F [US] ET AL MOONEY CHRISTOPHER FRANCIS [US] ET AL) 2 August 2007 (2007-08-02) paragraph [0022] - paragraph [0032] figures 1,2	1-24

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

[X] See patent family annex.

* Special categories of cited documents :

"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

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 January 2013	06/02/2013

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

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description (Release 11)", 3GPP STANDARD; 3GPP TS 23.246, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. SA WG2, no. V11.1.0, 8 March 2012 (2012-03-08), pages 1-66, XP050555338, [retrieved on 2012-03-08] paragraph 4.1 paragraph 5.1 paragraph 5.2 paragraph 5.6 paragraphs 8.2 to 8.5 paragraphs 8.7 to 8.8 paragraph 8.16 figure 1b -----	1-24
A	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs (Release 11)", 3GPP STANDARD; 3GPP TS 26.346, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. SA WG4, no. V11.0.0, 9 March 2012 (2012-03-09), pages 1-163, XP050580071, [retrieved on 2012-03-09] paragraphs 4.1 to 4.4 paragraph 4.4.1a paragraph 4.4.3 paragraph 4.4.6 figure 4 ----- -/--	1-24

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/060858

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 11)", 3GPP STANDARD; 3GPP TS 36.300, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. V11.1.0, 12 March 2012 (2012-03-12), pages 1-194, XP050580013, [retrieved on 2012-03-12] paragraph 15.10	1-24

E	US 2012/263089 A1 (GUPTA AJAY [US] ET AL) 18 October 2012 (2012-10-18) paragraph [0083] - paragraph [0088] paragraph [0101] - paragraph [0103] figures 6A, 9B, 11	1-24

E	US 2013/007287 A1 (CHU THOMAS P [US] ET AL) 3 January 2013 (2013-01-03) paragraph [0035] - paragraph [0055] figures 4,5	1-24

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/060858

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007177592 A1	02-08-2007	NONE	
US 2012263089 A1	18-10-2012	US 2012263089 A1	18-10-2012
		WO 2012142428 A1	18-10-2012
US 2013007287 A1	03-01-2013	NONE	