(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 343 808 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
04.07.2018 Bulletin 2018/27

(51) Int Cl.:
H04H 20/38 *(2008.01)* ***H04H 60/07*** *(2008.01)*
H04H 60/91 *(2008.01)* *H04H 20/42* *(2008.01)*

(21) Application number: **17305399.2**

(22) Date of filing: **03.04.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **30.12.2016 EP 16306858**

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(54) ADAPTATION OF BROADCASTING PARAMETERS BASED ON FEEDBACK DATA

(57) The invention relates to a method for adapting broadcasting parameters of a broadcast layer in a hybrid unicast/broadcast network comprising the broadcast layer dedicated to transmission of at least one broadcast service and a unicast layer dedicated to transmission of at least one unicast service, the method being carried out in at least one network entity and comprising the following steps:
- receiving (401) feedback data issued from at least one user equipment via the unicast layer;
- deriving (402), from the feedback data, information related to the at least one broadcast service broadcasted in the broadcast layer;
- transmitting (403) the derived information to a decision entity so as to adapt at least one broadcasting parameter of the at least one broadcast layer based on the derived information.

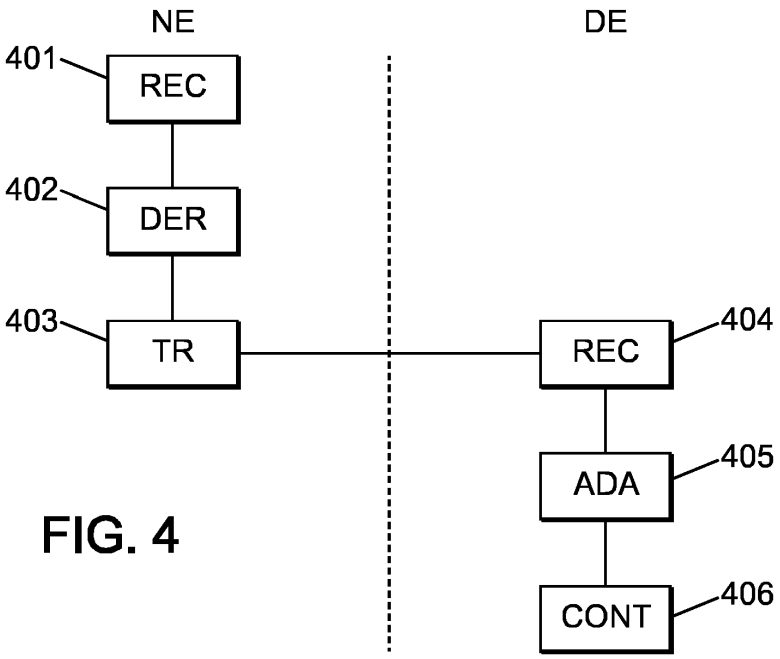

FIG. 4

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Description

[0001] The present invention generally relates to the adaptation of parameters for transmission of broadcast services in particular in the context of a hybrid broadcast/unicast network.

[0002] It finds application, in particular while not exclusively, in systems that enable to offload broadcast services from a cellular network, such as an LTE mobile network, in particular LTE-Advanced, which is initially dedicated to unicast services, to an existing broadcast network. Such networks aim in particular at relieving mobile networks by offloading broadcast contents, such as video contents, to existing High Tower, High Power (HTHP) transmitters of broadcast networks. This system is hereafter called Tower Overlay over LTE-Advanced+, TOoL+.

[0003] Within the framework of the present invention, a hybrid broadcast/unicast network encompasses any network or network system that comprises at least one broadcast layer and at least one unicast layer.

[0004] LTE-Advanced describes the latest evolution of cellular transmission standards developed by the 3GPP (Third Generation Partnership Project).

[0005] For example, when LTE-A broadcast data are offloaded to HTHP transmitters, the data transmitted by the HTHP transmitters can be referred to as LTE-A+ data.

[0006] Traditional terrestrial broadcast networks using, for example, DVB-T2 (Digital Video Broadcasting - Terrestrial, 2nd generation) or ATSC (Advanced Television Systems Committee), apply fixed modulation and coding modes and other fixed broadcasting parameters, such as guard interval or transmission power, according to respective coverage requirements and network planning.

[0007] Using a fixed networking planning leads to a suboptimal resource usage : the fixed broadcasting parameters are chosen to enable reception of the broadcast service for the user equipments whose location (far away from the HTHP) and reception conditions (for example deep-indoor or high velocity outdoor) having the highest need on transmission robustness. This limits the overall system performance and throughput for all the other users with possibly better reception conditions

[0008] In addition, all locations where reception should be possible are permanently served (fixed coverage area), although some user equipments may be turned off occasionally.

[0009] On the other hand, in many cases, additional user equipments could be reached (extension of the fixed coverage area) if slightly more robust broadcasting parameters were used.

[0010] Different broadcast services are usually broadcasted by the HTHP transmitter using broadcasting parameters irrespective of their respective current popularities.

[0011] There is therefore a need to dynamically adapt the broadcasting parameters of a broadcast layer so as to enhance the overall performance of a hybrid unicast/broadcast network.

[0012] The invention aims at improving the situation.

[0013] To this end, the invention relates to a method for adapting broadcasting parameters of a broadcast layer in a hybrid unicast/broadcast network comprising the broadcast layer dedicated to transmission of at least one broadcast service and a unicast layer dedicated to transmission of at least one unicast service, the method being carried out in at least one network entity and comprising the following steps:

- receiving feedback data issued from at least one user equipment via the unicast layer;
- deriving, from the feedback data, information related to the at least one broadcast service broadcasted in the broadcast layer;
- transmitting the derived information to a decision entity so as to adapt at least one broadcasting parameter of the at least one broadcast layer based on the derived information.

[0014] The unicast layer therefore enables to obtain feedback data related to the broadcast layer, via an uplink channel for example. An enhanced collaboration between the two layers (belonging to the same network or to two different networks) can therefore enable to dynamically adapt broadcasting parameters based on information derived from the feedback data. Advantageously, feedback data from several user equipments can be accumulated, so that the broadcasting parameters are optimized. This may enable to optimize the overall:

- data rate;
- signal quality/Quality of Service, QoS;
- coverage area;
- operational expenditures, OPEX;
- frequency usage; and/or
- others.

[0015] According to some embodiments, the method may further comprise the following steps, carried out by the decision entity:

- receiving the derived information from the network entity;
- adapting the at least one broadcasting parameter based on the received derived information;
- controlling a broadcast transmitter based on the adapted broadcasting parameters.

[0016] The decision entity and the network entity can be separate, as they can belong to different networks. For example, the network entity is an entity of a mobile network, dedicated at least to unicast services, such as an LTE-A network, whereas the decision entity may belong to a network originally dedicated to broadcast transmission and can therefore control HTHP transmitters. In

that case, the hybrid unicast/broadcast network is a network system comprising a broadcast network and a network dedicated at least to unicast services (but also eventually to broadcast services). Alternatively, when the decision entity and the network entity belong to one and the same network that is a hybrid unicast/broadcast, they can be grouped in a single entity.

[0017] According to some embodiments, the method may further comprise receiving, by the decision entity, complementary data from a third party, and the at least one broadcasting parameter can be adapted based on the received derived information and based on the received complementary data.

[0018] The complementary data can for example be broadcast service popularity forecast data or weather forecast data. This enables to optimize the adaptation of the broadcasting parameters.

[0019] According to some embodiments, the feedback data may comprise :

- an indicator of the reception quality of at least one user equipment receiving the at least one broadcast service;
- a location identifier of at least one user equipment receiving the at least one broadcast service; and/or
- an identifier of a current or future usage of the broadcast service.

[0020] All or some of these elements may be taken into account as they are relevant for optimizing the use of resources of the broadcast layer or of the overall system.

[0021] In complement, the information related to the at least one broadcast service and derived from the feedback data, or the complementary data, may comprise:

- a reception condition if the feedback data comprises at least the indicator of the reception quality of the at least one user equipment;
- a current or predicted local weather if the feedback data comprises at least the location identifier of the at least one user equipment or at least the indicator of the reception quality of the at least one user equipment;
- a current or predicted content popularity if the feedback data comprises the identifier of the current or future usage of the broadcast service.

[0022] Therefore, many possible different information can be taken into account when adapting the parameters, so that the resources of the hybrid unicast/broadcast network are optimized.

[0023] According to some embodiments, the at least one parameter may comprise a length of a guard interval for the transmission of the at least one broadcast service.

[0024] For example, a shorter guard interval in combination with an associated shorter useful symbol duration, can lead to a higher robustness against frequency offsets and Doppler shifts.

[0025] According to some embodiments, the unicast/broadcast network may comprise a unicast network for transmission of the unicast services via the unicast layer, and a separate broadcast network for transmission of the broadcast service via the broadcast layer.

[0026] For example, the unicast network can be an LTE-A network. The whole network system can therefore be a TOoL+ system as described above.

[0027] Alternatively, the network can be a LTE-A network, the unicast layer can be dedicated to transmission of mobile unicast services and the broadcast layer can be dedicated to transmission of evolved Multimedia Broadcast Multicast Services, eMBMS.

[0028] Therefore, the present invention enables to optimize the broadcast parameters of the eMBMS layer of a LTE-A network.

[0029] According to some embodiments, the at least one broadcasting parameter may comprise at least one element among:

- a modulation scheme of the at least one broadcast service;
- a Forward Error Correction, FEC, code rate of the at least one broadcast service; and/or
- a transmission power of the at least one broadcast service.

[0030] These parameters are already adapted for unicast transmissions, so that this principle can be extended to the broadcast layer according to the invention.

[0031] According to some embodiments, the broadcast layer may comprise multiplexed data pipes comprising at least a static data pipe providing a static base capacity and an additional data pipe providing a dynamic capacity, adapting the broadcast parameter may comprise modifying the dynamic capacity of the additional data pipe.

[0032] This enables to enhance the network throughput, in particular in the context of favorable reception conditions by the user equipments (for example, a sunny weather). A possibility to implement such multiplexed data pipes on the physical layer is hierarchical modulation. On the application layer, the use of scalable coding (for example scalable video coding) may offer a robust base data pipe featuring low quality and a less robust extension layer offering a quality improvement.

[0033] According to some embodiments, adapting the broadcasting parameter comprises the shutdown of the broadcast layer when the derived information indicates a low usage of the at least one broadcast service.

[0034] This enables to save energy and transmission costs.

[0035] A second aspect of the invention concerns a computer program product, with a program stored thereon, said program being configured for, when executed by a processor, perform the steps of a method according to the first aspect of the invention.

[0036] A third aspect of the invention concerns a net-

work entity in a hybrid unicast/broadcast network comprising the broadcast layer dedicated to transmission of at least one broadcast service and a unicast layer dedicated to transmission of at least one unicast service, comprising:

- a first interface configured for receiving feedback data issued from at least one user equipment via the unicast layer;
- a controller configured for deriving, from the feedback data, information related to the at least one broadcast service broadcasted in the broadcast layer;
- a second interface configured for transmitting the derived information to a decision entity so as to adapt at least one broadcasting parameter of the at least one broadcast layer based on the derived information.

[0037] A fourth aspect of the invention concerns a hybrid unicast/broadcast network comprising a network entity according to the third aspect of the invention and further comprising a decision entity comprising:

- an interface configured for receiving the derived information from the network entity;
- a controller configured for adapting the at least one broadcasting parameter based on the received derived information and for controlling a broadcast transmitter based on the adapted broadcasting parameters.

[0038] According to some embodiments, the interface can be further configured to receive complementary data from a third party, and the controller can be configured for adapting the at least one broadcasting parameter based on the received derived information and based on the complementary data

[0039] A fifth aspect of the invention concerns a user equipment comprising :

- a first interface unit for receiving at least one broadcast service via a broadcast layer;
- a processor configured for obtaining an identifier of a current or future usage of the broadcast service;
- a second interface unit transmitting feedback data via a unicast layer;

[0040] The feedback data may comprise the identifier of the current or future usage of the broadcast service.

[0041] The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings, in which like reference numerals refer to similar elements and in which:

- Figure 1 illustrates a network according to some embodiments of the invention.
- Figure 2 represents a HTHP transmitter according to a first scenario;
- Figure 3 represents a HTHP transmitter according to a second scenario;
- Figure 4 is a flowchart illustrating the steps of a method according to some embodiments of the invention;
- Figure 5 illustrates a structure of a network entity according to some embodiments of the invention;
- Figure 6 illustrates a structure of a decision entity according to some embodiments of the invention;
- Figure 7 illustrates an adaptation of the broadcast capacity according to some embodiments of the invention.

[0042] Referring to Figure 1, there is shown a Tower Overlay over LTE-A+ system, called TOoL+ system, which comprises a HTHP transmitter 10 of a broadcast network having a first coverage area 14, and several nodes 11.1 and 11.2 of a broadband network, such as an LTE-A mobile broadband network, the nodes 11.1 and 11.2 having respective second coverage areas 12.1 and 12.2. Nodes 11.1 and 11.2 can be base stations, which are called eNodeBs under LTE-A specifications.

[0043] A User Equipment, UE, 13.1 can be located inside the second coverage area 12.1 and inside the first coverage area 14, so as to receive both services provided by the HTHP transmitter 10 and by the eNodeB 11.1. UEs 13.2 and 13.3 can be located inside the second coverage area 12.2 and inside the first coverage area 14, so as to receive both services provided by the HTHP transmitter 10 and by the eNodeB 11.2.

[0044] LTE-A+ designates transmission of LTE-A services via the HTHP transmitter 10. These services can be received and decoded by any user equipment having a LTE-A+ decoding unit and an antenna for demodulating signals transmitted by the HTHP transmitter 10. A LTE-A+ decoding unit is arranged to decode LTE-A+ frames that are broadcasted by the HTHP transmitter 10.

[0045] The example of a TOoL+ system is considered hereafter, for illustrative purposes. However, the invention applies to any hybrid unicast/broadcast network and is not restricted to the TOoL+ system.

[0046] Indeed, the hybrid unicast/broadcast network or network system encompasses any network or network system that provides at least one broadcast layer supporting transportation of at least one broadcast service and at least one unicast layer supporting transportation of at least one unicast service. Alternatively or in complement to the TOoL+ system, the two layers can be implemented by the classical LTE-A network, where the broadcast layer corresponds to an eMBMS layer, and the unicast layer is a LTE-A unicast layer.

[0047] However, in what follows, we mainly (but not exclusively) consider, for illustrative purpose only, a hybrid unicast/broadcast network that is a TOoL+ system, whereby the adapted broadcasting parameters are those of the HTHP transmitter 10.

[0048] A broadcast network designates a network,

which is originally designed to be dedicated to services other than unicast services, such as broadcast or multicast services.

[0049] The principle of Tower Overlay over LTE-A+, TOoL+, is to offload data originally transmitted through broadband networks, such as LTE networks, especially live video or other popular contents, to broadcast networks, for example networks initially dedicated to broadcast television services.

[0050] Therefore, LTE-A broadcast services that were originally transmitted by the mobile network, using enhanced Multimedia Broadcast Multicast Service, eMBMS, for example, can be transmitted by an HTHP transmitter 10 instead of an eNodeB 11.1-11.2 of the LTE-A mobile broadband network.

[0051] According to the invention, the hybrid unicast/broadcast network comprises a network entity 15, which will be detailed hereafter, and which is in charge of collecting feedback data from the eNodeBs of the broadband network, and to derive information related to the broadcast service from the feedback data. The hybrid unicast/broadcast network also comprises a decision entity 16 which will be detailed hereafter and which is configured to use the derived information to adapt broadcasting parameters. In the embodiment shown on Figure 1, the decision entity 16 is located in the vicinity of the HTHP transmitter 10, which is only illustrative and because the broadcast layer is carried by the HTHP transmitter 10 is this specific embodiment. In the embodiment, where the broadcast layer is supported by the broadband network, such as the eMBMS layer of a LTE-A network, the decision entity 16 is arranged to control the broadcasting parameters of the eMBMS layer.

[0052] The TOoL+ system according to the invention encompasses at least two HTHP scenarios that are illustrated on Figures 2 and 3.

[0053] According to a first scenario that is illustrated on Figure 2, the broadcast network comprising the HTHP transmitter 10 carries LTE-A+ broadcast services only. In that case, the HTHP transmitter 10 comprises a LTE-A+ modulator 21 and an antenna 22. The LTE-A+ modulator 21 is arranged to receive data, such as video data or audio data, to be encoded in a format that satisfies the LTE-A specifications.

[0054] In that example, all the time-frequency resources of the HTHP transmitter 10 are dedicated to the transportation of LTE-A+ broadcast content and control data, thereby addressing all UEs that are compatible with the LTE-A specifications and within the first coverage area 14. Therefore, the antenna 22 broadcasts only LTE-A+ frames 23.1-23.4 in the first coverage area 14.

[0055] According to a second scenario that is illustrated on Figure 3, the broadcast network carries both LTE-A+ broadcast services and DVB-T2 services.

[0056] To this end, the HTHP transmitter 10 comprises an LTE-A modulator 32 and a DVB-T2 modulator 31. The LTE-A+ modulator 32 is arranged to transmit data, such as video data or audio data, encoded in a format that satisfies the LTE-A+ specifications. The DVB-T2 modulator 31 is arranged to transmit data, usually video data, encoded in a format that satisfies the DVB-T2 specifications.

[0057] The HTHP transmitter 10 may also comprise a multiplexer 33 to multiplex the data issued from the modulators 31 and 32 and to transmit the multiplexed data to an antenna 34.

[0058] For example, and as shown on Figure 3, the data issued from the modulators 31 and 32 can be time-multiplexed, so that one or several DVB-T2 frames 35.1 and 35.3 are alternated with one or several LTE-A+ frames 35.2 and 35.4 when broadcasted by the antenna 34 in the first coverage area 11.

[0059] A single antenna 34 has been shown on Figure 3. However, the invention is not restricted to this example and also encompasses the case where an antenna is dedicated to each of the modulators 31 and 32. In that case, the antennas need to be synchronized so as to ensure that the LTE-A+ frames and the DVB-T2 frames are timely alternated.

[0060] Of course, the HTHP transmitter 10 shown on Figure 3 can also be used in the first scenario, and can alternate between the first and second scenarios upon demand. In addition, the HTHP transmitter 10 can alternate between more than two different services, or can alternate between services other than LTE-A+ and DVB-T2.

[0061] As explained above, the present invention enables to dynamically adapt broadcasting parameters, such as parameters of the LTE-A+ modulators 21 or 31 and antennas 22 and 34.

[0062] Referring back to Figure 1, the UEs 13.1-13.3 are configured for receiving and decoding broadcast service data, such as LTE-A+ data, transmitted by the HTHP transmitter 10, provided they are located within the first coverage area 14.

[0063] However, within the first coverage area 14, several sub-areas may be associated with different coverage levels that generally decrease while the distance from the HTHP transmitter 10 increases.

[0064] For example, some UEs are more distant from the HTHP transmitter 10 than other UEs, and errors are likely to occur on the broadcast channel for the distant UEs.

[0065] Figure 4 is a flowchart illustrating steps of a method according to some embodiments of the invention.

[0066] At step 401, the network entity 15 receives feedback data issued from at least one UE and transmitted in upstream to the serving eNodeB via the unicast layer. Feedback data encompasses any data that is issued by one of the UEs 13.1 to 13.3 via the unicast network, and may comprise:

- LTE-A Channel State Information, CSI, or more generally any indicator of the reception quality of the at least one UE receiving the at least one broadcast service, such as a Doppler shift or a maximum ex-

cess delay;

- a location identifier of at least one user equipment receiving the at least one broadcast service. This can be for example Global Positioning Service, GPS, data fed back by the UE to the serving eNodeB, or can be a location identifier of the serving eNodeB; and/or
- an identifier of a current or future usage of the broadcast service, or more generally an identifier of the broadcast service that is received (and output or displayed) by the UE. For example, the UE indicates in a feedback message which usage of the broadcast service is made by the user of the UE. Usage may encompass the displayed multimedia content, multimedia resolution, broadcast data rate.

[0067] As it can be understood, the network entity 15 preferably gathers feedback data from a plurality of UEs that are potentially served by different eNodeBs in the broadband network. The network entity 15 can therefore be a centralized entity, or can be dedicated to a given geographical zone of the broadband network.

[0068] At step 402, the network entity 15 derives, from the feedback data, possibly issued from several UEs, information related to the at least one broadcast service broadcasted via the broadcast layer. No restriction is attached to the information, which can comprise:

- broadcast reception conditions, which can be derived from the CSI fed back by the UE or the UEs. Preferably the broadcast reception conditions are representative of the conditions of several UEs, and are therefore preferably derived from several indicators of the reception quality received from respective UEs. For example, the reception conditions can be an average value, a result of a comparison between CSI and a threshold value, or any data that can be derived from the indicator of the reception quality. The users experiencing channel conditions that are lower than the average value, or the users among the X% having the worst reception conditions can for example be cut off from the broadcast layer, to be served by a complementary broadcast layer such as eMBMS or to be served via unicast;
- the current or predicted local weather. For example, if it is determined that most UEs are concentrated in a given sub-area of the first coverage area (this can be obtained by the feedback data comprising location identifiers), then local weather data corresponding to this sub-area can be obtained. Also the current weather can be determined based on the indicators of reception quality fed back by the UEs. For example, under a bad weather, users are likely to prevent going outdoors and to stay indoors, where the channel conditions are usually more attenuated due to walls. No restriction is attached to the retrieval of weather data. For example, weather data can be retrieved from a database by inputting a location identifier ;
- the distribution (of the locations) of users in the first coverage area 14, which can be derived from the location identifiers fed back by the UE or the UEs;
- the current or predicted popularity of the different broadcast services, which can be derived from the identifier of the respective current or future usages of the broadcast service by the UE or the UEs or more generally from the identifiers of the broadcast service. Popularity can be global, i.e. over a global population covered by several eNodeBs, or can be linked to one or some coverage areas of a subset of eNodeBs. Indeed popularity of a given broadcast service can be varying due to sociodemographic features for example.

[0069] The present invention is not limited to the derived information that is given above for illustrative purposes only.

[0070] At step 403, the network entity 15 transmits the derived information to the decision entity 16 so as to adapt at least one broadcasting parameter of the at least one broadcast layer based on the derived information.

[0071] As shown on Figure 4, steps 401 to 403 can be performed by the network entity 15. The following steps 404 to 406 can be performed by the decision entity 16. According to some embodiments of the invention, the network entity 15 and the decision entity can be grouped in one and the same entity. This is particularly advantageous in the context where the broadcast layer and the unicast layer are carried by the LTE-A network (unicast LTE-A layer and eMBMS).

[0072] At step 404, the decision entity 16 receives the derived information from the network entity 15. In addition to the derived information received from the network entity 15, the decision entity can receive complementary data from other sources, such as broadcasting service popularity forecasts or weather forecasts.

[0073] At step 405, the decision entity 16 adapts at least one broadcasting parameter based on the received derived information, and optionally based on the complementary information. No restriction is attached to what is meant by "broadcasting parameter" as it encompasses any parameter relied to the broadcast transmission of the at least one broadcast service via the broadcasting layer (through the HTHP transmitter 10 in the specific embodiment illustrated on Figure 1). Examples of broadcasting parameters will be described hereafter.

[0074] At step 406, the decision entity 16 controls a broadcast transmitter (the HTHP transmitter 10 or an eNodeB used for eMBMS) based on the adapted broadcasting parameters.

[0075] Figure 5 illustrates a structure of the network entity 15 according to some embodiments of the invention.

[0076] The network entity 15 comprises a random access memory 503 and a processor 502 that can execute instructions to perform at least step 402 as described

above.

[0077] The network entity 15 also comprises a database 504. The database 504, according to some embodiments, can store the instructions to be executed by the processor 502 so as to perform at least step 402. It can further store the feedback data received from the eNodeBs and the derived information. It can also store weather data, forecast weather data, current or predicted popularities of broadcast services. All the stored data can be regularly updated by external entities.

[0078] The network entity 15 may further comprise a first network interface 501 for communicating with at least one eNodeBs, and preferably with several eNodeBs. The network entity 15 may comprise a network interface dedicated for each of the eNodeBs with which it communicates.

[0079] The network entity 15 may further comprise a second network interface 505 for communicating with the decision entity 16. As explained above, this can be an interface that is internal to the LTE-A network in the case where the broadcast layer is the eMBMS layer, or the interface can be between the broadband network and the broadcast network comprising the HTHP transmitter 10, in the case where the broadcast layer is supported by the HTHP transmitter 10.

[0080] Figure 6 illustrates a structure of the decision entity 16 according to some embodiments of the invention.

[0081] The decision entity 16 comprises a random access memory 603 and a processor 602 that can execute instructions to perform at least step 405 and 406 as described above.

[0082] The decision entity 16 also comprises a database 604. The database 604, according to some embodiments can store the instructions to be executed by the processor 602. It can further store the derived information received from the network entity 15. It can also store weather data, forecast weather data, current or predicted popularities of broadcast services. All the stored data can be regularly updated by external entities.

[0083] The network entity 16 may further comprise a first network interface 601 for communicating with the network entity 15. As explained above, this can be an interface that is internal to the LTE-A network in the case where the broadcast layer is the eMBMS layer, or the interface can be between the broadband network and the broadcast network comprising the HTHP transmitter 10, in the case where the broadcast layer is supported by the HTHP transmitter 10.

[0084] The network entity 16 may further comprise a second network interface 605 for communicating with broadcast transmitters, such as the HTHP transmitter 10 or the eNodeBs carrying eMBMS.

[0085] In what follows, detailed embodiments of adaptation of broadcasting parameters based on the received derived information are described.

[0086] The at least one broadcasting parameter that can be adapted by the decision entity 16 may comprise :

- a modulation scheme of the at least one broadcast service;
- a Forward Error Correction, FEC, code rate of the at least one broadcast service;
- a transmission power of the at least one broadcast service.

[0087] These parameters are also optimized in classical mobile networks, but are limited to the optimization of individual unicast connections. However, the present invention takes advantage of the hybrid unicast/broadcast network comprising a unicast layer that can be used for feeding back information from the UEs. This offers a possible optimization of the overall network performance (also in terms of costs). According to some embodiments, the network is a network system comprising two broadcast layers : for example it can include the broadcast layer supported by the HTHP transmitter 10 and another broadcast layer that is an eMBMS layer of the mobile broadband network, within a TOoL+ network system. In that case, the use of the three layers can be optimized by adapting broadcasting parameters for both broadcast layers.

[0088] Alternatively or in complement, the at least one broadcasting parameter may comprise a pilot pattern position of reference symbols, a length of guard interval and/or time allocation to DVB-T2 and LTE-A+ for the HTHP transmitter 10 in case of the second scenario illustrated on Figure 3.

[0089] In the event where all UEs experience channel conditions (derived from the feedback data) that are similar to a certain extent (for example, similar Doppler shifts, similar maximum excess delays, etc.), the pilot pattern of the broadcast layer can be adapted by the decision entity 16 to meet these channel conditions and to reduce the overhead induced by an unnecessarily high density of pilot signals.

[0090] Furthermore, the decision entity 16 can adapt the guard interval dynamically. For example, a short guard interval can be sufficient for error free transmission for certain HTHP broadcast scenarios. See for example the article of the inventor S. Ilsen and Al, "Tower Overlay over LTE-Advanced+ (TOoL+): Results of a Field Trial in Paris", Proc. IEEE BMSM, 2016.

[0091] The decision entity 16 can therefore shorten the guard interval based on the channel conditions experienced by the UEs.

[0092] A shorter guard interval in combination with the associated shorter useful symbol duration leads to a higher subcarrier spacing of multi-carrier waveforms (such as in OFDM) and thus to a higher robustness against frequency offsets and Doppler shifts. Alternatively, the useful symbol duration can be chosen as fixed by the decision entity 16, thereby enabling a higher total throughput for the broadcast layer.

[0093] Also, when the derived information comprises current or predicted local weather or when the weather data is received as complementary data from a third party

(weather forecast service), the adapted parameters can be a robustness level of the broadcast transmission via the broadcast layer. For example, if some UEs are located in a geographical zone where a rainy weather is forecasted for a given period, the robustness level of the broadcast transmission can be increased during said period.

[0094] The decision entity 16 can therefore continuously adapt the broadcasting parameters based on the received derived information, and optionally based on complementary information received from a third party. For example, the network entity 15 can directly forward the derived information as soon as it has been determined. In that case, the decision entity 16 is configured to adapt the parameters upon reception of the derived information, and optionally upon reception of the complementary information. Alternatively, the network entity 15 can transmit the derived information that are gathered from all the UEs, at a regular time interval (at a given frequency). In that case, the decision entity 16 can adapt the broadcasting parameters according to this regular time interval, therefore with a higher safety margin.

[0095] Therefore, the decision entity 16 can adapt the broadcasting parameters dynamically based on the information derived from the feedback data issued from the different UEs, and optionally based on complementary information received from a third party.

[0096] In addition, due to the multi-layer approach of TOoL+, the decision entity 16 can adapt parameters by decreasing the robustness level to provide a higher throughput of the LTE-A+ broadcast carrier transmitted by the HTHP transmitter 10. Then, UEs that are no longer served by the HTHP transmitter 10 due to the robustness decrease can be served using the unicast layer or the eMBMS layer of the broadband network.

[0097] According to another embodiment, in the event where the derived information and/or the complementary information indicates favorable weather conditions and/or indicates good reception conditions of the UEs, the decision entity 16 can increase the data transmission rate on the broadcast layer, while the coverage area remains the same.

[0098] This can be realized by the usage of multiplexed data pipes. For example, there can be the following data pipes in the broadcast layer:

- a static data pipe providing a static base capacity; and
- an additional data pipe providing a dynamic capacity.

[0099] Referring to Figure 7, there is illustrated a static base capacity 701 of the static data pipe and a dynamic capacity 702 of the additional data pipe. As can be seen on the figure, the derived information, such as the current and predicted weather can be used to dynamically adjust the dynamic capacity 702 of the additional data pipe. In case of favorable weather conditions (sun without clouds), the dynamic capacity 702 can be increased whereas in case of bad weather conditions (rain) the dynamic capacity 702 can be reduced, to avoid wasting resources.

[0100] The data pipes can multiplexed on the physical layer by hierarchical modulation. Also, on the application layer, the use of scalable video coding (in case of a broadcast service corresponding to a video) may offer a robust base data pipe featuring a low video quality and a less robust extension layer offering a quality improvement.

[0101] The invention also encompasses an embodiment where, in case of low usage (the derived information indicates that few UEs are consuming the broadcast service), such as for example during the night, a shutdown of the broadcast layer can be performed so as to save energy and transmission costs.

[0102] As another example, if a broadcast service has a high current or predicted popularity (from the derived information or from complementary information issued by a third party), the broadcasting parameters can be adapted to increase the robustness of the broadcast service to as to reach as many users as possible. In addition, the dynamic capacity of the additional data pipe as described above can be used for scalable coding of the popular broadcast service. On the other hand, broadcast services with a low popularity can be broadcasted with a lower robustness on the broadcast layer or can be moved from the HTHP transmitter 10 to the mobile network.

[0103] In addition, the relevance of the feedback data can be filtered by radio network controllers of the unicast network, such as for example the eNodeBs in the LTE-A network. For example, only a fraction of all the CSIs of a coverage area 12.1-12.2 can be used to determine derived information to be sent to the decision entity 16.

[0104] By adapting the broadcasting parameters, the present invention makes it possible to optimize the overall :

- data rate;
- signal quality/Quality of Service, QoS;
- coverage area;
- operational expenditures, OPEX;
- unicast/eMBMS cell load, in the case where eMBMS is used as broadcast layer; and/or
- frequency usage.

[0105] The signaling of adapted broadcasting parameters to the HTHP transmitters lead to an overhead, which is therefore small compared to the benefits of the invention.

[0106] Figure 8 illustrates a detailed structure of a UE 13 according to some embodiments of the invention.

[0107] The UE 13 comprises a first interface 801, which is arranged to receive radiofrequency signals via a broadcast layer. For example, the broadcast layer can be broadcasted by the HTHP transmitter 10 or can correspond to the eMBMS layer of the mobile network. The first interface 801 can therefore be an antenna.

[0108] The UE 13 also comprises a synchronization unit 803, a demodulation unit 804 and a channel decoding unit 805 and a de-multiplexing unit 806. These units are configured for decoding the broadcast service received via the first interface 801. As their functioning is well known, it is not further described in the present application.

[0109] The UE 13 further comprises a second interface 802 according to the invention. The second interface 802 is configured to transmit feedback data on a unicast layer. The unicast layer can be an uplink layer of the broadband network, i.e. of the LTE-A network.

[0110] The UE 13 further comprises a processor 807 and a random access memory (RAM) 808, that are configured for determining feedback data to be transmitted via the second interface 802. The feedback data, as explained above, can be:

- an indicator of the reception quality;
- a location identifier of the UE 13. To this end, the UE 13 can comprise a GPRS unit, which is not represented on Figure 8; and/or
- an identifier of a current or future usage of the broadcast service.

[0111] It is to be noted that, according to some embodiments, the first interface 801 and the second interface 802 can be one and the same interface, in particular when the broadcast layer is the eMBMS layer of the LTE-A network.

Claims

1. A method for adapting broadcasting parameters of a broadcast layer in a hybrid unicast/broadcast network comprising the broadcast layer dedicated to transmission of at least one broadcast service and a unicast layer dedicated to transmission of at least one unicast service, the method being carried out in at least one network entity (15) and comprising the following steps:

   - receiving (401) feedback data issued from at least one user equipment (13.1-13.3) via the unicast layer;
   - deriving (402), from the feedback data, information related to the at least one broadcast service broadcasted in the broadcast layer;
   - transmitting (403) the derived information to a decision entity (16) so as to adapt at least one broadcasting parameter of the at least one broadcast layer based on the derived information.

2. The method according to claim 1, further comprising the following steps, carried out by the decision entity:

   - receiving (404) the derived information from the network entity;
   - adapting (405) the at least one broadcasting parameter based on the received derived information;
   - controlling (406) a broadcast transmitter (10; 11.1-11.2) based on the adapted broadcasting parameters.

3. The method according to claim 2, further comprising receiving, by the decision entity, complementary data from a third party, and wherein the at least one broadcasting parameter is adapted based on the received derived information and based on the received complementary data.

4. The method according to one of claims 1 to 3, wherein the feedback data comprises:

   - an indicator of the reception quality of at least one user equipment (13.1-13.3) receiving the at least one broadcast service;
   - a location identifier of at least one user equipment receiving the at least one broadcast service; and/or
   - an identifier of a current or future usage of the broadcast service.

5. The method according to claim 4, wherein the information related to the at least one broadcast service and derived from the feedback data, or complementary data, comprises :

   - a reception condition if the feedback data comprises at least the indicator of the reception quality of the at least one user equipment (13.1-13.3);
   - a current or predicted local weather if the feedback data comprises at least the location identifier of the at least one user equipment or at least the indicator of the reception quality of the at least one user equipment;
   - a current or predicted content popularity if the feedback data comprises the identifier of the current or future usage of the broadcast service.

6. The method according to one of the preceding claims, wherein the unicast/broadcast network comprises a unicast network for transmission of the unicast services via the unicast layer, and a separate broadcast network for transmission of the broadcast service via the broadcast layer.

7. The method according to claim 6, wherein the unicast network is an LTE-A network.

8. The method according to one of claims 1 to 5, wherein the network is a LTE-A network, wherein the uni-

cast layer is dedicated to transmission of mobile unicast services and wherein the broadcast layer is dedicated to transmission of evolved Multimedia Broadcast Multicast Services, eMBMS.

9. The method according to one of the preceding claims, wherein the at least one broadcasting parameter comprises at least one element among:

- a modulation scheme of the at least one broadcast service;
- a Forward Error Correction, FEC, code rate of the at least one broadcast service; and/or
- a transmission power of the at least one broadcast service.

10. The method according to one of the preceding claims, wherein the broadcast layer comprises multiplexed data pipes comprising at least a static data pipe providing a static base capacity and an additional data pipe providing a dynamic capacity, wherein adapting the broadcast parameter comprises modifying the dynamic capacity of the additional data pipe.

11. The method according to one of the preceding claims, wherein adapting the broadcasting parameter comprises the shutdown of the broadcast layer when the derived information indicates a low usage of the at least one broadcast service.

12. A computer program product, with a program stored thereon, said program being configured for, when executed by a processor, perform the steps of a method according to one of claims 1 to 11.

13. A network entity (15) in a hybrid unicast/broadcast network comprising the broadcast layer dedicated to transmission of at least one broadcast service and a unicast layer dedicated to transmission of at least one unicast service, comprising:

- a first interface (501) configured for receiving feedback data issued from at least one user equipment (13.1-13.3) via the unicast layer;
- a controller (502) configured for deriving, from the feedback data, information related to the at least one broadcast service broadcasted in the broadcast layer;
- a second interface (505) configured for transmitting the derived information to a decision entity (16) so as to adapt at least one broadcasting parameter of the at least one broadcast layer based on the derived information.

14. A hybrid unicast/broadcast network comprising a network entity (15) according to claim 13 and further comprising a decision entity (16) comprising:

- an interface (601) configured for receiving the derived information from the network entity;
- a controller (602) configured for adapting the at least one broadcasting parameter based on the received derived information and for controlling a broadcast transmitter (10; 11.1-11.2) based on the adapted broadcasting parameters.

15. The hybrid unicast/broadcast network according to claim 14, wherein the interface (601) is further configured to receive complementary data from a third party, and wherein the controller (602) is configured for adapting the at least one broadcasting parameter based on the received derived information and based on the complementary data.

16. A user equipment comprising :

- a first interface unit for receiving at least one broadcast service via a broadcast layer;
- a processor configured for obtaining an identifier of a current or future usage of the broadcast service;
- a second interface unit transmitting feedback data via a unicast layer;

wherein the feedback data comprises the identifier of the current or future usage of the broadcast service.

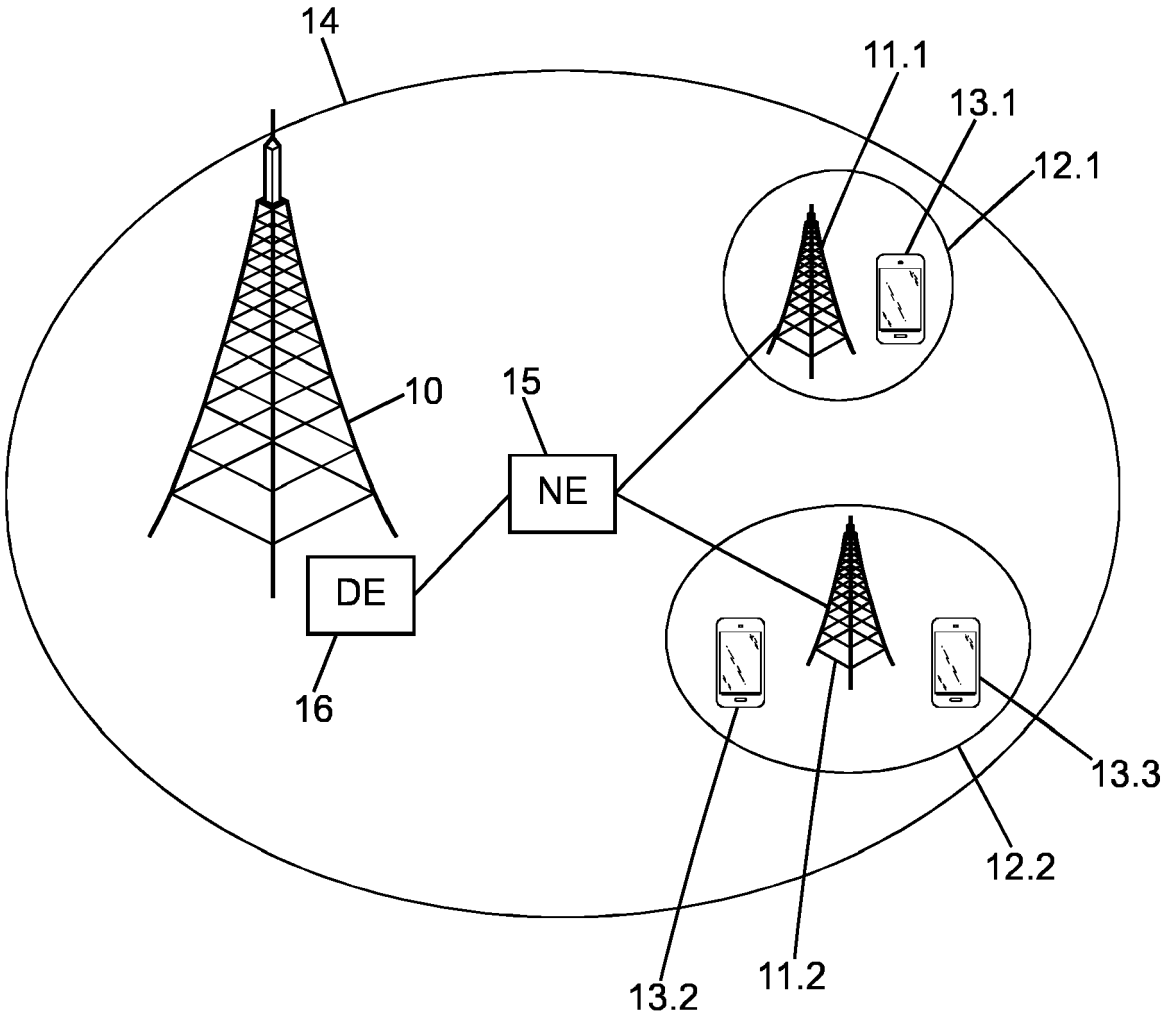
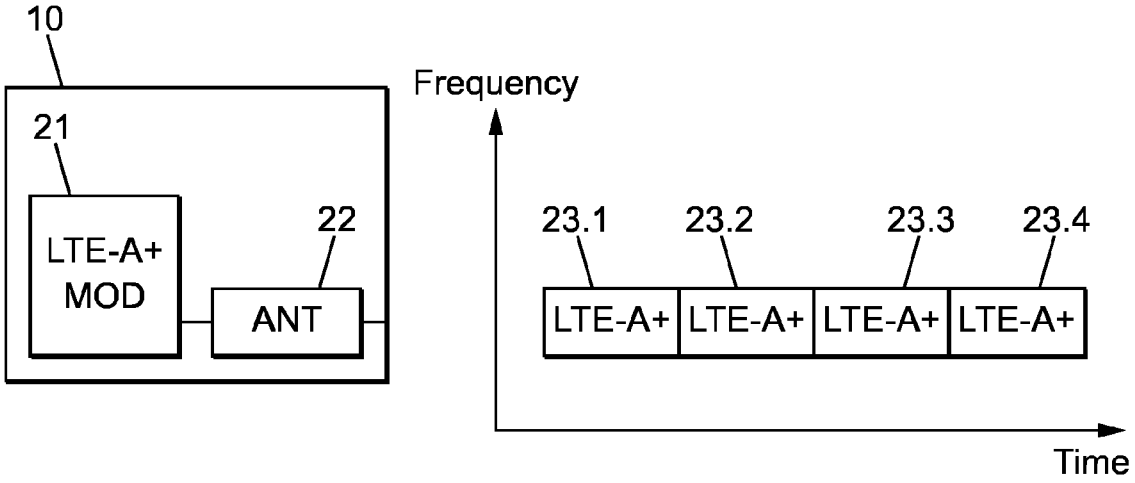


FIG. 1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MOD
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ANT
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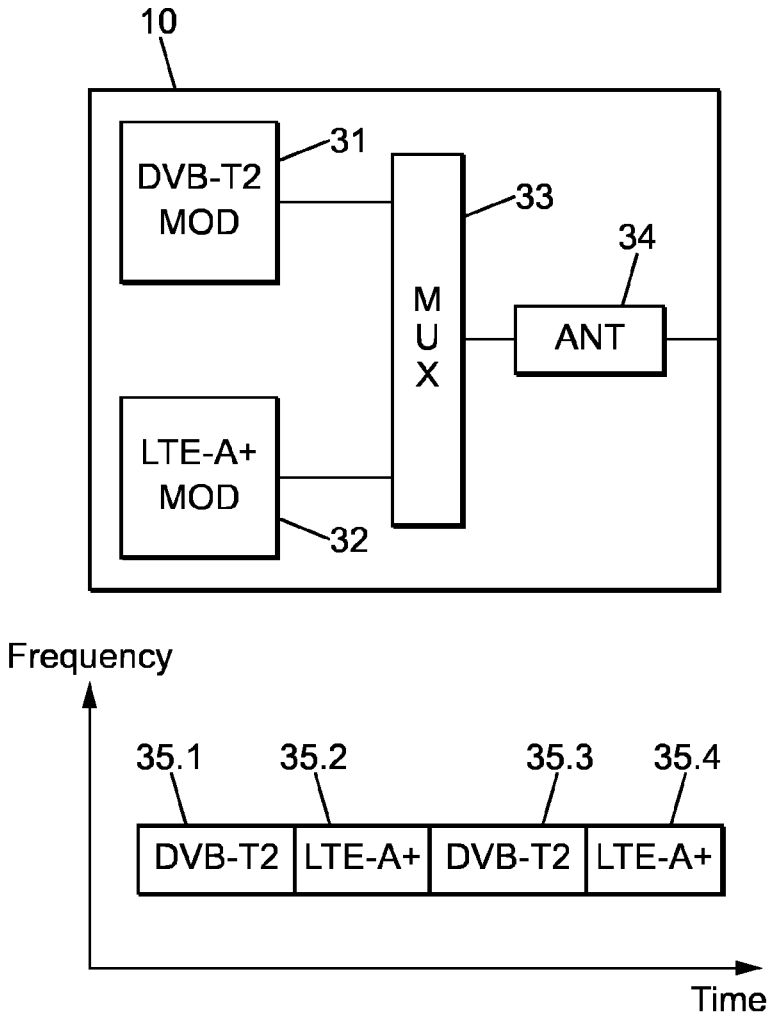
LTE-A+
LTE-A+
Time

FIG. 2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MOD
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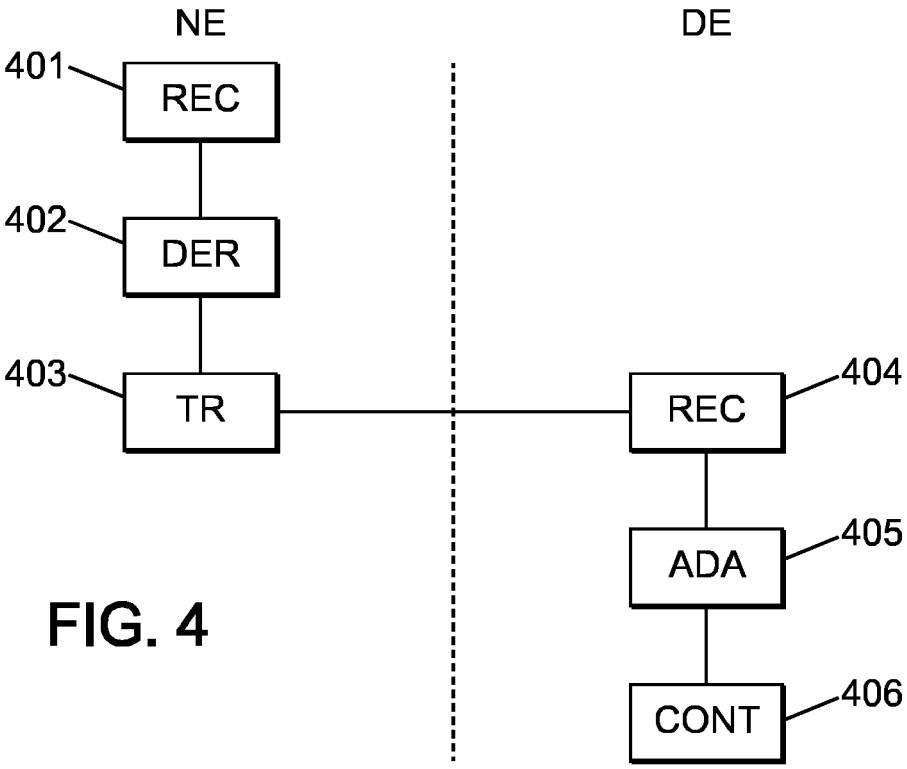
LTE-A+
DVB-T2
LTE-A+
Time

FIG. 3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402
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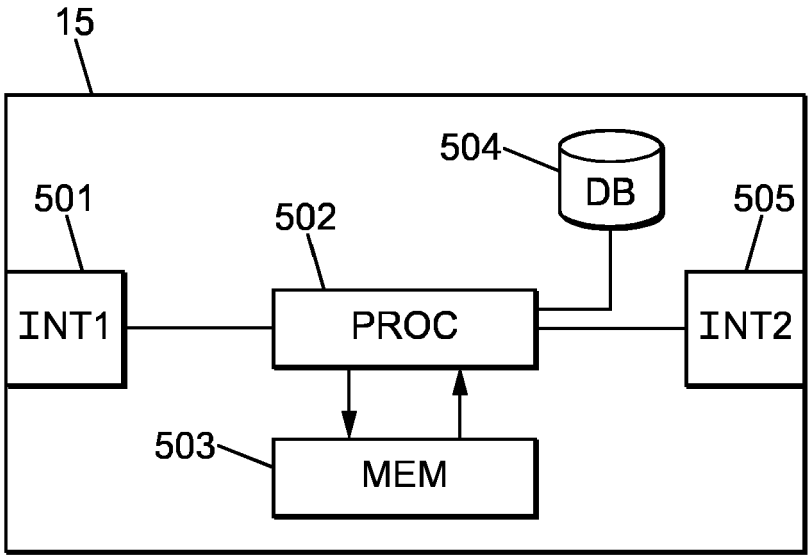
ADA
405
CONT
406

FIG. 4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501
502
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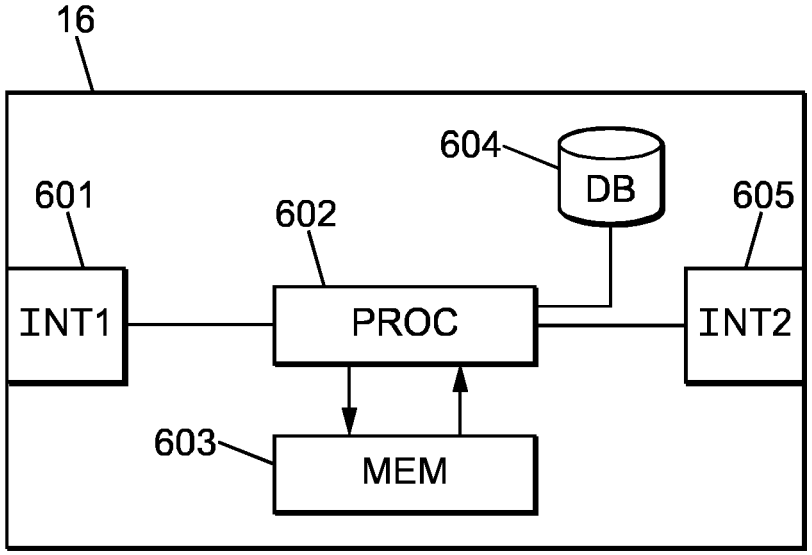
INT1
PROC
INT2
503
MEM

FIG. 5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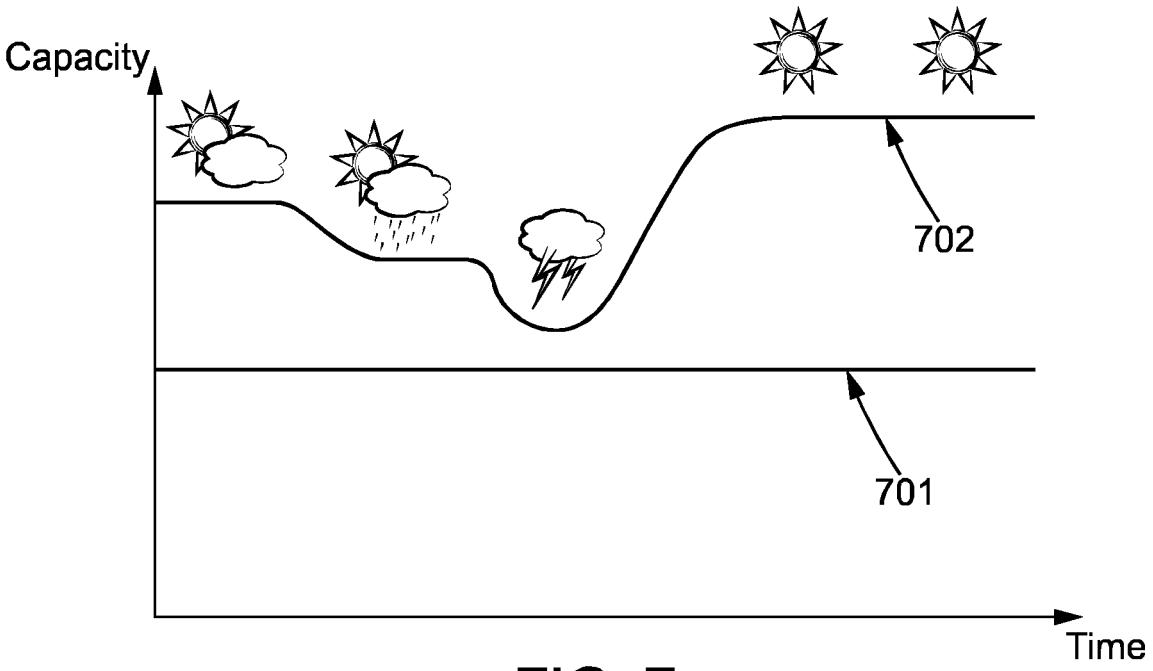
604
DB
601
602
605
INT1
PROC
INT2
603
MEM

FIG. 6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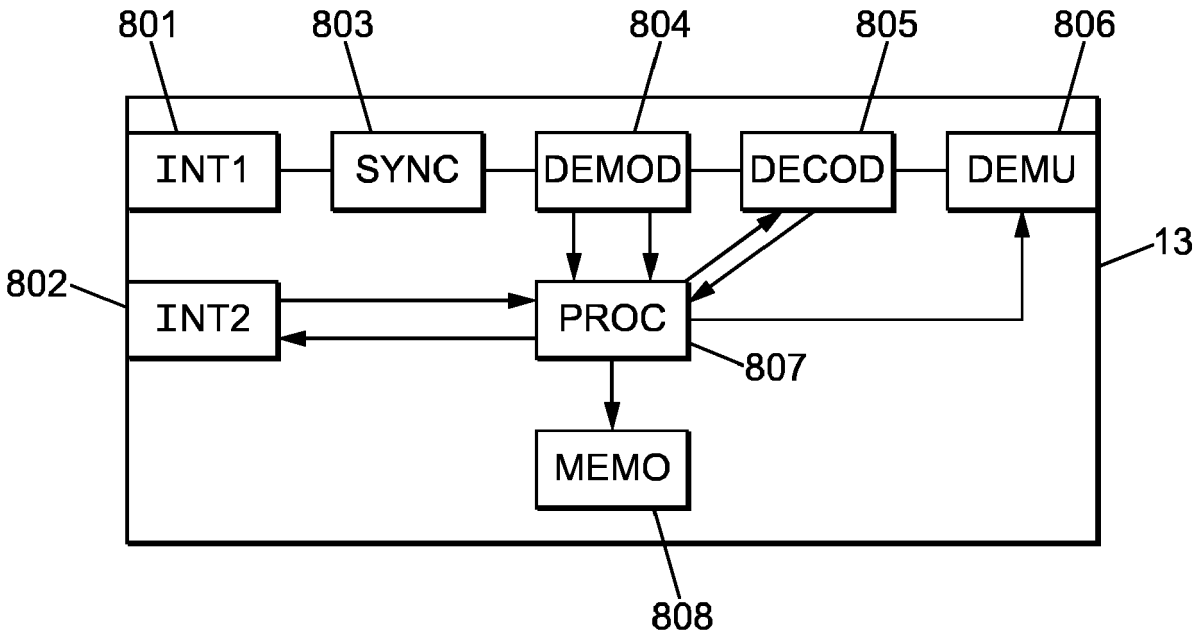
Time

FIG. 7


801
803
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INT1
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808

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 17 30 5399

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2006/105010 A1 (NEOCIFIC INC [US]; HUANG HAIMING [US]; LI XIAODONG [US]; LO TITUS [US]) 5 October 2006 (2006-10-05) * paragraphs [0028] - [0031] * * paragraph [0044] * * paragraph [0051] * * paragraph [0055] * * paragraphs [0058] - [0061] * * paragraphs [0067] - [0068] * * claim 2 * * claim 11 *	1-5, 8-10, 12-15	INV. H04H20/38 H04H60/07 H04H60/91 ADD. H04H20/42
X	US 2013/254828 A1 (REIMERS ULRICH [DE] ET AL) 26 September 2013 (2013-09-26) * paragraph [0003] * * paragraph [0005] * * paragraph [0048] * * figure 1 * * paragraph [0050] * * paragraph [0052] * * paragraphs [0054] - [0056] * * paragraph [0062] * * figure 3 * * paragraphs [0074] - [0075] *	1,2,4-7, 9,11-14, 16	TECHNICAL FIELDS SEARCHED (IPC) H04N H04H
X	US 2013/044668 A1 (PURNADI RENE WARAPUTRA [US] ET AL) 21 February 2013 (2013-02-21) * paragraph [0001] * * paragraph [0003] * * paragraphs [0030] - [0031] * * paragraph [0091] *	16	
A	GB 2 486 742 A (WIRELESS TECH SOLUTIONS LLC [US]) 27 June 2012 (2012-06-27) * page 1, lines 6-9 * * page 4, lines 22-28 * * page 6, lines 31-34 *	8	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27 October 2017	Torcal Serrano, C

CATEGORY OF CITED DOCUMENTS

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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27-10-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2006105010 A1	05-10-2006	CN 1969475 A	23-05-2007
		CN 102833685 A	19-12-2012
		US 2008198785 A1	21-08-2008
		US 2012063381 A1	15-03-2012
		US 2012327897 A1	27-12-2012
		US 2014133444 A1	15-05-2014
		WO 2006105010 A1	05-10-2006
US 2013254828 A1	26-09-2013	US 2013254828 A1	26-09-2013
		US 2015288990 A1	08-10-2015
		US 2017055008 A1	23-02-2017
US 2013044668 A1	21-02-2013	EP 2745557 A1	25-06-2014
		TW 201313045 A	16-03-2013
		US 2013044668 A1	21-02-2013
		WO 2013025235 A1	21-02-2013
GB 2486742 A	27-06-2012	CN 103430577 A	04-12-2013
		DE 112011104544 T5	26-09-2013
		GB 2486742 A	27-06-2012
		US 2013343259 A1	26-12-2013
		WO 2012085543 A1	28-06-2012

EPO FORM P0459

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REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- **S. ILSEN.** Tower Overlay over LTE-Advanced+ (TOoL+): Results of a Field Trial in Paris. *Proc. IEEE BMSM,* 2016 **[0090]**