

METHOD AND SYSTEM FOR DISTRIBUTION IN A MIXED POINT-TO-MULTIPOINT AND POINT-TO-POINT (D2D) NETWORK

The invention relates to a method and a system making it possible
5 to distribute a content (multimedia service) to a set of users (or mobile devices) in a mixed communication network using the technology of point-to-multipoint and device-to-device or point-to-point or D2D transmission. It is applied for network topologies comprising a source and multiple destinations which can be reached, either through a simple point-to-multipoint radio
10 communication, or through multi-hop short-range communications.

The invention can be used in the field of wireless networks which make joint use of point-to-multipoint and D2D device-to-device communications.

There is an ever stronger demand for multimedia services on the
15 part of users.

By utilizing the broadcasting nature of the wireless channel, point-to-multipoint radio communications use a single radio connection shared between several user equipments within one and the same radio cell. The user equipments UE receive the same content, allowing, in principle, very
20 efficient use in terms of radio resources used at the base station.

Point-to-multipoint radio communications of this type exhibit problems which limit their efficiency, notably (i) the obligation to dimension the system while taking account of the user with the worst channel, (ii) the total absence of reliability. The modulation and the coding or MCS of the
25 transmission must both be sufficiently robust to ensure reception for each user. Accordingly, the modulation and the coding of the transmission are either fixed and very conservative, or adapted to the most unfavorable conditions, i.e., the worst channel among the set of users, this dictating the overall performance of the communication cell.

30 By counting on D2D communications as a supplement to point-to-multipoint radio transmissions, it is possible to improve performance as

regards bitrate provided to the users. Instead of reaching the whole set of users present under the radio coverage of the cell with the same point-to-multipoint radio transmission, it is possible to reach just a subset of them, the users who exhibit the best channel quality, while utilizing multi-hop D2D
 5 communications to relay the transmission to the other users. This makes it possible to use at the base station a point-to-multipoint transmission with a much more efficient channel modulation and coding.

In the case of the LTE (Long Term Evolution) standard, the allocation of the resources and the scheduling of the transmissions are
 10 controlled by the base station and relayed to the user equipments UE using control channels such as the physical downlink control channel PDCCH, the physical multicast control channel PMCH and the uplink control channel PUCCH (Physical Uplink Control Channel). These decisions can comprise the modulation and the coding of the point-to-multipoint transmission, the
 15 allocation of the D2D communications between the UEs and the scheduling of the packets on these links. The decisions are taken on the basis of connectivity and quality of links (user equipment UE-base station BS and UE-UE) information relayed periodically by the user equipments, for example by means of channel quality indicator CQI messages in the LTE specification.

20 Finding the optimal allocation of the resources and streams is a problem which is complex. The problem arises, notably, when the number of variables in play increases (number of users, of links between users, or else of radio resources RR to be allocated), because the complexity of such an approach grows exponentially. In this case, it is very difficult to satisfy the
 25 delays required by the channel adaptation (a few milliseconds, depending on the mobility of the user equipments and the size of the allocation).

Point-to-multipoint distribution in a wireless network, in order to offer multimedia services in an efficient manner, was introduced initially into version 6 of the cooperation project for 3GPP (specification of the WCDMA)
 30 third-generation networks. However, the capability to transmit data to a multitude of recipients is also essential for group communications in the case

of a public security scenario. The 3GPP cooperation has recently evaluated various specifications and architectures which allow radio point-to-multipoint transmissions. In particular, in the latest versions of the specifications for the various services: multimedia multiple broadcasting service or “evolved
 5 *Multimedia Broadcast and Multicast Service*» (eMBMS), group communication systems or “*Group Communications System Enablers*” (GCSE), point-to-multipoint transmission with a single cell “*Single-Cell Point-to-Multipoint*” (SC-PTM) and the walkie-talkie service for critical communications or “*Mission Critical Push to Talk*” (MCPTT) have been fine
 10 tuned.

In particular, *eMBMS* represents the first specification which makes it possible to define a single network frequency or *single frequency network (SFN)* and a base station subset in a geographical zone which provide a point-to-multipoint IP service on the same frequency. In such a
 15 context, the quantity of radio resources consumed for the point-to-multipoint communication is independent of the number of user equipments in the group, this being advantageous from a point of view of the use of the radio resources.

However, a limitation of the use of several base stations
 20 transmitting on the same frequency is the inability to use channel adaptation due to the absence of a return channel. Consequently, the base station eNB is forced to use a very robust modulation and coding technique, which is fixed at the outset, thus leading to degraded spectral efficiency and negatively influencing the bitrate offered to the user equipments UE.

A more efficient solution in terms of radio resources is described in the specification of *SC-PTM*, which can be considered to be the fusion of the point-to-point and eMBMS transmission techniques. *SC-PTM* represents a radio access procedure dedicated to the point-to-multipoint communications on an individual cell and by reusing communication channels customarily
 30 used for point-to-point transmissions. For this reason, contrary to eMBMS, SC-PTM has the possibility of using various techniques of channel adaptation

(Adaptive Modulation and Coding - AMC) and of automatic retransmission HARQ (Hybrid Automatic Repeat Request), while being more efficient and reliable.

The use of D2D communications coupled with *SC-PTM* or *eMBMS* communications can further improve the efficiency of content distribution to a group.

To the applicant's knowledge, there does not exist any solution making it possible to allocate resources in a multi-hop D2D and point-to-multipoint radio network. The prior art describes protocols for content distribution with the aid of D2D communications and as a supplement to multicast transmissions.

The prior art uses D2D communications coupled with multicast. For example, the D2D-SF method is a method making it possible to utilize D2D communications to relay a multicast stream while improving the cell's overall bitrate. In its main implementation, the D2D-SF method elects relay nodes (cluster heads), having a relay function, which are in charge of effecting the link between the base station BS and the other user equipments by D2D communications. Each relay node is in charge of a cluster of nodes. The relay nodes are elected by taking account of the quality of the link which connects them to the base station BS.

Let us consider the case where the base station BS has some content to be transmitted by multicast:

- The qualities of the cellular links (between BS and UE) and of the D2D links (between UE) are received and ordered at the base station through the channel quality information CQI messages,
- For each value m of the modulation and coding scheme MCS:
 - o The multicast group which can sustain the MCS m is sought,
 - o In this group, the relay nodes are determined, according to the quality of their D2D link in relation to the other UEs,
 - o The radio resources are allocated at the level of the base station and of the D2D links,

- If the configuration is achievable, i.e., all the nodes are covered and the resources are available, the overall bitrate of the cell is preserved and the method considers the following value of m ,
- 5 ○ In the converse case, the method selects the configuration which maximizes the overall bitrate of the cell.

This solution therefore makes it possible to increase the global bitrate through the network and to improve the spectral efficiency. In this case, all the selected relay nodes transmit the packet in a single hop. This mode of
 10 operation amounts to a transmission D2D in a single hop with the election of a cluster head.

In the approach known by the expression "*joint multicast/D2D learning-based approach*", automatic learning algorithms are implemented to detect the size of the group of the multicast (and the transmission MCS)
 15 which minimizes the use of radio resources RR at the base station BS. The D2D communications are of multi-hop opportunistic type, and are not scheduled by the base station, which limits itself to evaluating the result of the D2D broadcasting process. In this strategy, the D2D communications take place on a different band (IEEE 802.11) from that of the point-to-
 20 multipoint transmissions (LTE).

Other solutions known from the prior art have tried to improve the efficiency of point-to-multipoint transmissions without using D2D communications.

For example, in the document entitled "Optimized Opportunistic
 25 Multicast Scheduling (OMS) over Wireless Cellular Networks", T.-P. Low, and M.-O. Pun, and Y.-W. P. Hong, and C.-C. Jay Kuo, IEEE Transactions on Wireless Communications, 2010, the authors consider a mechanism which transmits in multicast in each timeslot to subsets of different user equipments UE.

30 By using different transmit bitrates, in the document "Radio Resource Management for Group-Oriented services in LTE-A", L. Militano,

and D. Niyato, and M. Condoluci, and G. Araniti, and A. Iera, and G. Molica Bisci, In IEEE Transactions on Vehicular Technology, 2015, the authors target subsets of user equipments with similar channel quality. The sub-groups are formed with a negotiation approach.

5 In the document "Fair and optimal resource allocation for LTE multicast (eMBMS): Group partitioning and dynamics", J. Chen, and M. Chiang, and J. Erman and G. Li, and K. K. Ramakrishnan, and R. K. Sinha, INFOCOM 2015, the sub-groups are formed via an optimization process which takes account of the proportional equity of their bitrate and of the
10 usage of radio resources at the base station.

 The document entitled "Group Communication over LTE: a radio access perspective", J. Kim, and S. W. Choi, and W. Y. Shin, and Y. S. Song, and Y.K. Kim, IEEE Communications Magazine, 2016, proposes a HARQ retransmissions coding mechanism for SC-PTM so as to improve the
15 efficiency of the point-to-multipoint transmissions.

 In the subsequent description, the expressions "user equipment", "user" or "mobile device" and "UE" or "UE_k" are employed to designate a user in a communication network. Similarly, the word "link" designates the expression "radio channel".

20 The method and the system according to the invention is based on a novel approach which gives joint consideration to problematic issues of allocation of resources, scheduling and routing, in a mixed radio network using point-to-multipoint communication and D2D relays in order to improve the minimum bitrate provided for at a user equipment. This approach allows a
25 considerable improvement in performance in terms of bitrate for a multi-recipient stream in a radio cell. By using this technique, the transmit bitrate is no longer subject to the conditions of the "worst radio link" between the base station and the user equipments. This also allows maximum limitation of the disparities between the received bitrate and the bitrate receivable by the
30 users according to their channel quality.

The invention relates to a method for transmitting contents to a set of users UE_k in a wireless communication network, by using at one and the same time point-to-multipoint communications between at least one base station BS and several users UE_k and point-to-point or D2D relays between several users
 5 (UE_k - UE_k), characterized in that it allocates the radio resources by executing at least the following steps:

Measure or evaluate the quality of the radio links between the base station BS and the users UE_k ,

10 Measure or evaluate the quality of the D2D radio links between the various users UE_k ,

Select, as a function of the information regarding quality of links, one, and only one, subset of users MG_i^* , of cardinality greater than or equal to 1, and a modulation and coding scheme MCS to be used for the point-to-multipoint transmission performed by the base station so as to guarantee the capability
 15 to decode such a transmission to all the users forming part of the selected subset MG_i^* ,

Generate a tree A , of cardinality greater than or equal to 0, formed exclusively by links $UE_k \rightarrow UE_k$ (D2D) existing between the users to relay the content of the point-to-multipoint transmission from the users forming part of
 20 the subset MG_i^* as chosen in the previous step to all the others,

Allocate radio resources on the D2D connections defined by the tree A .

The method can comprise at least the following steps:

Consider the maximum index MCS i^* for the coding and modulation scheme of the point-to-multipoint transmission which covers the set of users UE_k of
 25 the network, initialize a variable $T_{old} = 0$,

Construct the set of user devices which have the capabilities to demodulate the message or messages coded and modulated with this coding and modulation scheme MCS i^* , which will form the multicast group MG_i^* , calculate the bitrate $M(i^*)$ for each user with this coding and modulation
 30 scheme,

For the users not having at their disposal capabilities to demodulate the messages coded with the scheme MCS i^* ,

- Construct a tree A composed of a set of links L which connect a mobile device UE_k not belonging to MG_i^* to one and only one mobile device UE_k belonging to the group MG_i^* ,
- Use an algorithm for allocating the resources on the links L thus defined,

Evaluate the value of minimum bitrate $D(i^*)$ allocated on the links L of the tree A , save the minimum value $T(i^*)$ corresponding to the minimum bitrate between $D(i^*)$ and the bitrate of the point-to-multipoint transmission $M(i^*)$,

If the bitrate on the D2D links, $D(i^*)$, is greater than the bitrate of the point-to-multipoint transmission $M(i^*)$, the bitrate of the point-to-multipoint transmission is retained as minimum bitrate therefore $T(i^*) = M(i^*)$, otherwise give the bitrate value the minimum value, $T(i^*) = D(i^*)$,

- $D(i^*)$ represents the minimum bitrate on the links L of the tree A in the algorithm for allocating the resources,
- $T(i^*)$ is the minimum between the bitrate on the links of the tree $D(i^*)$ and the bitrate on the multicast links $M(i^*)$, $T(i^*) = \min(D(i^*), M(i^*))$,

In the case where all the users belong to MG_i^* , then $T(i^*) = M(i^*)$,

If the bitrate allocated to the present links for the maximum index of the modulation coding scheme $T(i^*)$ is greater than or equal to the allocated bitrate for the index T_{old} :

- If the minimum bitrate allocated to the links $T(i^*) = M(i^*)$, the bitrate received at each user with the modulation and coding i^* ,
 - Save $T_{old} = T(i^*)$, pass to the modulation index $i^* = i^* + 1$ and return to the step of constructing the group MG_i^* ,
- Otherwise, if $T(i^*) < M(i^*)$,:
 - Return the value of MCS i^* and $Alloc_D2D(i^*)$,

Otherwise, $T(i^*)$ is less than T_{old} , return the value of MCS $i^* - 1$ and its D2D allocation, $Alloc_D2D(i^* - 1)$.

According to a variant embodiment, the method uses CQI messages to evaluate the quality of the links ($BS \rightarrow UE_k$ and $UE_k \rightarrow UE_k$).

The method can use the knowledge of the positions of the users and of the base station to evaluate the quality of the links ($BS \rightarrow UE_k$ and
5 $UE_k \rightarrow UE_k$).

According to a variant embodiment the tree A is constructed using an Edmonds-Chu algorithm.

The method uses a greedy algorithm for the allocation of the resources.

10 The method is executed within a processor of the base station, for example at the level of a scheduler block of the base station.

The method can allocate resources for the distributing of a content in a communication network supporting the LTE technology.

According to a variant embodiment, the method allocates
15 resources to distribute a content in a communication network using a TDMA channel division multiple access procedure.

The method uses, for example, a message chosen from among the messages "SCI", "DCI" and "SC-PTM configuration" and one of the channels available in the "LTE3", "PUCCH", "MCCH" and "PDCCH" standard
20 to transmit the allocation of resources which is chosen at the base station to the users UE_k .

The method uses, for example, specific signaling messages in a communication network using a TDMA channel access technique to notify the users UE_k of the allocation of resources which is chosen by the base
25 station.

The invention also relates to a system for allocating resources in a communication network supporting a point-to-multipoint communication between at least one base station and several users UE_k and point-to-point or D2D communications between several users (UE_k-UE_k), characterized in
30 that it comprises at least one processor adapted to allocate radio resources by executing at least the following steps:

Measure or evaluate the quality of the links $BS \rightarrow UE_k$ and in parallel the quality of the existing D2D links between several users, $UE_k \rightarrow UE_k$,

Select, as a function of the information regarding quality of the links, one, and only one, subset of users MG_i^* , of cardinality greater than or equal to 1, and a
 5 modulation and coding scheme to be used for the point-to-multipoint transmission performed by the base station so as to guarantee the capability to decode such a transmission to all the users forming part of the selected subset MG_i^* ,

Generate a tree A , of cardinality greater than or equal to 0, formed
 10 exclusively by links $UE_k \rightarrow UE_k$ (D2D) existing between the users to relay the content of the point-to-multipoint transmission from the users forming part of the subset MG_i^* as chosen in the previous step to all the others,

Allocate radio resources on the D2D connections defined by the tree A .

The processor adapted to execute the steps of the method
 15 according to the invention can be implemented at the level of a base station of the communication network or at the level of an application server dedicated to the management of group communications.

Other characteristics and advantages of the present invention will become better apparent on reading the description of exemplary
 20 embodiments given by way of wholly nonlimiting illustration, accompanied by the figures which represent:

- Figure 1, an exemplary communication network according to the invention,
- Figure 2, an illustration of the succession of steps implemented by the
 25 method according to the invention, and
- Figure 3, an exemplary implementation of the method.

In order to better elucidate the subject matter of the invention, the description which follows is given in the case of an exemplary specific use of the LTE and of its upgrades. However, without departing from the scope of
 30 the invention the case of use can be extended by taking into account an IEEE 802.11 Wi-Fi, or IEEE 802.16 WiMAX base station and D2D

communications which use channel access technologies such as time division multiple access or TDMA, or the media access or CSMA/CA (*Carrier Sense Multiple Access with Collision Avoidance*) procedure.

Figure 1 illustrates an exemplary communication network comprising a base station 1 and several recipient users or equipments UE_k , also called mobile devices. In Figure 1, the solid links I between the base station BS and the users UE_k correspond to a point-to-multipoint transmission and the dashed links II between two users UE_k correspond to D2D point-to-point transmissions.

The base station 1 comprises a processor 11 adapted to allocate radio resources by executing the steps, which will be described, of the method according to the invention and a communication module 12 for communicating with the users UE_k .

A user UE_k ($UE_1, UE_2, UE_3, UE_4, UE_5, UE_6$) or mobile device comprises communication means 13, a processor 14 adapted to measure the quality of links between the base station and/or a user of the network, or between two users.

Figure 2 illustrates the steps executed for example at the level of the base station and of the users, by relying on the following principle: on the basis of a regrowth of the measurements of the quality of the radio links, ($BS \rightarrow UE_k$ and/or $UE_k \rightarrow UE_k$), the method utilizes these data to determine:

- a subset of users MG_i^* , of cardinality greater than or equal to 1, which will receive the content of the point-to-multipoint transmission
- the modulation and coding scheme MCS to be used for the point-to-multipoint transmission performed by the base station so as to guarantee the capability to decode such a transmission to all the users forming part of the selected subset MG_i^* ,
- a tree A, of cardinality greater than or equal to 0, which connects all the users UE or UE_k not belonging to MG_i^* to one of the users belonging to the MG_i^* (optionally through the multi-hop D2D communications), the tree corresponds to the D2D links connecting at

least two mobile devices UE_k , phase of creation of the tree of resources on the D2D links. The union of the subset MGi^* chosen and of the vertices of the tree A cover the totality of the initial set of users.

- an allocation of resources on the D2D links of the tree A ,
5 $Alloc_D2D(i^*)$.

The method according to the invention advantageously makes it possible to maximize the minimum bitrate received at the level of each user and to improve the spectral efficiency.

The method illustrated in Figure 2 can be executed at the level of
10 the base station, inside the scheduling block or “scheduler” 20. The method can also be executed at the level of an application server dedicated to the management of group communications which is situated upstream of the core network. In the latter case, mechanisms for information exchanges between the base station and the server must be put in place according to
15 principles known to the person skilled in the art.

The method executed at the level of the processor 11 of the base station BS comprises, for example, the following steps, after reception or evaluation of the value of the quality of the radio channels of each user at the level of the base station:

20 Step 1,

Measure or evaluate the quality of the radio channels or the links between the base station BS and the users UE_k , $BS \rightarrow UE_k$, 201 and in parallel the quality of the radio channels or the D2D links which exist between the users, $UE_k \rightarrow UE_k$, 202, on the basis of the link quality indicators CQI received,
25 indicative of the capabilities of the radio links to sustain communications carried out with a certain modulation and coding scheme MCS. These two measurements can be carried out simultaneously. This step is equivalent to having the scheduler of the base station construct a connectivity graph $G(V,E)$, where V is the set of users UE_k , and $E=E1 \cup E2$ is the set of links
30 between the base station and a user $BS \rightarrow UE_k$ (E_1) and of links between

users D2D $UE_k \rightarrow UE_k$ (E_2) with, for each link, their hoped-for bitrate (in Mbps) as weight, for example, or some other metric of radio channel quality,

Step 2

Consider the maximum index of MCS (Modulation & Coding Scheme) of the point-to-multipoint transmission which covers all the UE_k in V ($i^* = \max\{i \text{ in } (0..15) \text{ s.t. } MCS_v \geq i \text{ for each } v \text{ in } V\}$), 201, initialize a variable T_{old} to zero, which variable is saved when the index i^* is incremented by one, $i^* = i^* + 1$,

Step 3

Construct the set of users UE_k covered by the point-to-multipoint transmission with MCS i^* - the users who have the capability to demodulate a message coded with MCS i^* . This set is called a *multicast group* (MG_{i^*}), 203. Calculate $M(i^*)$, the bitrate received at each user UE_k belonging to MG_{i^*} for a point-to-multipoint transmission with the modulation and coding index MCS i^* , 204,

Step 4

4 - 1 If some users do not belong to the multicast group MG_{i^*} , 205, then
 4 - 1.1 - Construct the tree A , 206, comprising the radio channels which connect each user UE_k not belonging to the group MG_{i^*} to one and only one user UE_k belonging to the group MG_{i^*} (optionally through several hops). This is done through a modified instance of the Edmonds-Chu algorithm, for example, which takes into account the measured quality of the D2D links, 202, (complexity of the algorithm $E_2 \log V \sim V^2 \log V$). The output A of the algorithm is a subset of the links in E_2 ,
 4 - 1.2 Use a greedy algorithm, for example, for the allocation of the resources on the D2D links, 207. This greedy algorithm takes into account the interference generated by the tree A by preventing the allocation of the same radio resource (PRB or TDMA slot, depending on the implementation chosen) to several interfering user equipments. The interference can be evaluated by the mobile devices or user equipments UE_k and transmitted to the base station by the CQI quality indicator messages or, by default, evaluated according to the user equipments' position estimated directly by

the base station. The greedy algorithm gives priority to the D2D links which exhibit low quality (small bitrate), so as to guarantee each user UE_k the max-min equity of the bitrates. The output of the algorithm $Alloc_D2D(i^*)$, 207, is the allocation of the resources on the D2D links. Its complexity is also of the

5 order of $A \log V \sim V^2 \log V$,

Evaluate the minimum bitrate allocated on the links of the tree A by $Alloc_D2D(i^*)$ called $D(i^*)$,

4 - 1.3 Save $T(i^*)$, which is the minimum bitrate between $D(i^*)$ calculated in step 4 - 1.2 and $M(i^*)$, the bitrate of the point-to-multipoint radio transmission

10 208,

If the bitrate on the D2D links, $D(i^*)$, is greater than the bitrate of the point-to-multipoint transmission $M(i^*)$, the bitrate of the point-to-multipoint transmission is retained as minimum bitrate therefore $T(i^*) = M(i^*)$, otherwise $T(i^*) = D(i^*)$,

- 15
- $D(i^*)$ represents the minimum bitrate on the D2D tree A in the allocation of the resources on the links, 207,
 - $T(i^*)$ is the minimum between the bitrate on the D2D links $D(i^*)$ and the bitrate on the multicast links $M(i^*)$, $T(i^*) = \min(D(i^*), M(i^*))$, 208,

20 4 - 2 Otherwise, in the case where all the users UE_k belong to MGi^* , $E=E_1$ and $T(i^*) = M(i^*)$, 209, i.e., there are no D2D links and the only bitrate to be considered is the point-to-multipoint bitrate.

At the first iteration, steps 4-1.1 4-1.3 are not executed and the method directly passes to step 4-2.

25 Step 5

If the bitrate allocated to the present links for the maximum index of the modulation coding scheme $T(i^*)$ is greater than or equal to the allocated bitrate for the index T_{old} , 210:

- 30
- If the minimum bitrate allocated to the links $T(i^*) = M(i^*)$, the bitrate of the point-to-multipoint transmission received at each user with the modulation and coding i^* , 211

- Save $T_{old} = T(i^*)$, pass to the modulation index $i^* = i^* + 1$, 212, and return to step 3,
- Otherwise, if $T(i^*) < M(i^*)$,:
 - Return the value of MCS i^* and $Alloc_D2D(i^*)$, 213,
- 5 Otherwise, $T(i^*)$ is less than T_{old} , return the value of MCS $i^* - 1$, 214 and its D2D allocation, $Alloc_D2D(i^* - 1)$.

The implementation of the method according to the invention involves the knowledge or the capability to estimate the quality of the radio channels or the D2D links between the users, as well as the quality of the D2D links between the base station and the users.

The quality of the D2D radio channels is, for example, estimated through the reception of the demodulation reference signal or DMRS and transmitted to the base station by reusing a feedback mechanism provided for the CQI quality indicator messages dispatched on the shared channel of the physical uplink PUSCH (Physical Uplink Shared Channel).

The quality of the radio channels between the base station and a user, or between two users, can be evaluated through the knowledge of the positions of the users and of the base station or else by using the CQI quality indicator messages.

Figure 3 illustrates the implementation of the method according to the invention at the level of the scheduling block or scheduler of the base station 1. The base station 1 comprises a module RRC 31 allowing the exchange of the signaling information between the user equipments and the base station. The MAC (Medium Access Control) link layer 32 comprises the scheduling block or Scheduler 20 in which the method according to the invention can be executed. The scheduling block 20 receives the information regarding quality of radio links CQI with the mobile devices or users. This information is transmitted, for example, on the basis of the physical link control channel PUCCH 33 in conjunction with a modulation/demodulation module 34 of the physical interface PHY 35 with the users.

According to the list of cells which is given by the multicell coordination entity or MCE, the multi-recipient data are transmitted to the corresponding base stations eNB (or BS). Each base station eNB thereafter transmits the information regarding resource allocations to the users UE_k through the downlink control information or DCI messages on the PDCCH (Physical Downlink Control CHannel) channel. The DCI messages differ as a function of the nature of the communications (point-to-multipoint or D2D). Each DCI message contains the allocation of resources and the group-related temporal identification information (G-RNTI – Group Radio Network Temporal Identifier). The information related to membership in the G-RNTI is acquired on the basis of configuration messages on the MCCH (Multicast Control CHannel). The datum dispatched under point-to-multipoint is thereafter transmitted on the downlink shared channel PDSCH (Physical Downlink Shared CHannel) or the multicast traffic channel MTCH (Multicast Traffic CHannel), according to the scheme chosen by the entity MCE (Multi-cell Coordination Entity, SC-PTM or SF-eMBMS). The users UE_k who have the capability thereto can decode this transmission. The users UE_k who, on the contrary, do not succeed in decoding will use the D2D channel with the allocation of resources which is provided by the base station eNB on the control channel PUCCH.

According to a variant embodiment, the method notifies the users UE_k of the allocation of resources which is chosen at the base station by using one of the following messages “SCI”, “DCI” and “SC-PTM configuration” and one of the channels available in the “LTE3”, “PUCCH”, “MCCH” and “PDCCH” standard.

According to another variant, the method notifies the users UE_k of the allocation of resources which is chosen by the base station by using specific signaling messages in a communication network using a TDMA channel access technique to notify the users UE_k of the allocation of resources which is chosen by the base station.

The method according to the invention offers notably the following advantages:

- Within the framework of an LTE application, an improvement in the overall bitrate offered by the LTE cell, and to each user,
- 5 • Better equity of content distribution to the users or a better overall bitrate of the cell,
- Low complexity compared with the optimal approach, with performance very close to optimal allocation; with a possibility of real-time implementation,
- 10 • The possibility of putting the method in place at various locations, directly integrated into the base station in the scheduling block, or at an application level on the server in charge of group communications.

CLAIMS

- 1 – A method for transmitting contents to a set of users UE_k in a wireless communication network, by using at one and the same time point-to-multipoint communications between at least one base station BS (1) and several users UE_k and point-to-point or D2D relays between several users (UE_k - UE_k), wherein it allocates the radio resources by executing at least the following steps:
- Measure or evaluate the quality of the radio links between the base station BS and the users UE_k (201),
- Measure or evaluate the quality of the D2D radio links between the various users UE_k (202),
- Select, as a function of the information regarding quality of links, one, and only one, subset of users MG_i^* , of cardinality greater than or equal to 1, and a modulation and coding scheme MCS to be used for the point-to-multipoint transmission performed by the base station so as to guarantee the capability to decode such a transmission to all the users forming part of the selected subset MG_i^* ,
- Consider the maximum index MCS i^* for the coding and modulation scheme of the point-to-multipoint transmission which covers the set of users UE_k of the network, initialize a variable $T_{old} = 0$,
- Construct the set of user devices which have the capabilities to demodulate the message or messages coded and modulated with this coding and modulation scheme MCS i^* , which will form the multicast group MG_i^* , (203, 204), calculate the bitrate $M(i^*)$ for each user with this coding and modulation scheme,
- For the users not having at their disposal capabilities to demodulate the messages coded with the scheme MCS i^* ,
- Construct a tree A composed of a set of links L which connect a mobile device UE_k not belonging to MG_i^* to one and only one mobile device UE_k belonging to the group MG_i^* (206),
- Use an algorithm for allocating the resources on the links L thus defined (207),

Evaluate the value of minimum bitrate $D(i^*)$ allocated on the links L of the tree A , save the minimum value $T(i^*)$ corresponding to the minimum bitrate between $D(i^*)$ and the bitrate of the point-to-multipoint transmission $M(i^*)$,

5 If the bitrate on the D2D links, $D(i^*)$, is greater than the bitrate of the point-to-multipoint transmission $M(i^*)$, the bitrate of the point-to-multipoint transmission is retained as minimum bitrate therefore $T(i^*) = M(i^*)$, otherwise $T(i^*) = D(i^*)$,

- $D(i^*)$ represents the minimum bitrate on the links L of the tree A in the algorithm for allocating the resources (207),
- 10 • $T(i^*)$ is the minimum between the bitrate on the links of the tree $D(i^*)$ and the bitrate on the multicast links $M(i^*)$, $T(i^*) = \min(D(i^*), M(i^*))$, (208)

In the case where all the users belong to MG_i^* , then $T(i^*) = M(i^*)$, (209),

15 If the bitrate allocated to the present links for the maximum index of the modulation coding scheme $T(i^*)$ is greater than or equal to the allocated bitrate for the index T_{old} , (210):

- If the minimum bitrate allocated to the links $T(i^*) = M(i^*)$, the bitrate received at each user with the modulation and coding i^* , (211)
 - Save $T_{old} = T(i^*)$, pass to the modulation index $i^* = i^* + 1$, (212), and
 - 20 return to the step of constructing the group MG_i^* ,
- Otherwise, if $T(i^*) < M(i^*)$,:
 - Returning the value of MCS i^* and $Alloc_D2D(i^*)$, (213),

Otherwise, $T(i^*)$ is less than T_{old} , return the value of MCS $i^* - 1$, (214) and its D2D allocation, $Alloc_D2D(i^* - 1)$,

25 Allocate radio resources on the D2D connections defined by the tree A .

2 – The method as claimed in claim 1, wherein it uses CQI messages to evaluate the quality of the links ($BS \rightarrow UE_k$ and $UE_k \rightarrow UE_k$),

30 3 – The method as claimed in claim 1, wherein it uses the knowledge of the positions of the users and of the base station to evaluate the quality of the links ($BS \rightarrow UE_k$ and $UE_k \rightarrow UE_k$).

4 – The method as claimed in claim 1, wherein the tree A is constructed using an Edmonds-Chu algorithm.

5 5 – The method as claimed in claim 1, wherein for the allocation of the resources a greedy algorithm is used.

6 – The method as claimed in claim 1, wherein the method is executed within a processor of the base station.

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7 – The method as claimed in claim 6, wherein the steps are executed at the level of a scheduler block (20) of the base station BS.

8 – The method as claimed in one of the preceding claims, wherein it allocates
15 resources for the distributing of a content in a communication network supporting the LTE technology.

9 – The method as claimed in one of claims 1 to 8, wherein it allocates
resources to distribute a content in a communication network using a TDMA
20 channel access technique.

10 – The method as claimed in one of claims 1 to 9, wherein it uses a message
chosen from among the messages “SCI”, “DCI” and “SC-PTM configuration”
and one of the channels available in the “LTE3”, “PUCCH”, “MCCH” and
25 “PDCCH” standard to transmit the allocation of resources which is chosen at the
base station to the users UE_k .

11 – The method as claimed in claim 9, wherein it uses specific signaling
messages in a communication network using a TDMA channel access
30 technique to notify the users UE_k of the allocation of resources which is chosen
by the base station.

- 12 – A system for allocating resources in a communication network supporting a point-to-multipoint communication between at least one base station BS (1) and several users UE_k and point-to-point or D2D relays between several users (UE_k - UE_k), wherein it comprises at least one processor adapted to allocate radio
- 5 resources by executing at least the following steps:
- Measure or evaluate the quality of the links $BS \rightarrow UE_k$, (201) and in parallel the quality of the existing D2D links between several users, $UE_k \rightarrow UE_k$, (202),
- Select, as a function of the information regarding quality of the links, one, and only one, subset of users MG_i^* , of cardinality greater than or equal to 1, and a
- 10 modulation and coding scheme to be used for the point-to-multipoint transmission performed by the base station so as to guarantee the capability to decode such a transmission to all the users forming part of the selected subset MG_i ;
- Consider the maximum index MCS i^* for the coding and modulation scheme of
- 15 the point-to-multipoint transmission which covers the set of users UE_k of the network, initialize a variable $T_{old} = 0$,
- Construct the set of user devices which have the capabilities to demodulate the message or messages coded and modulated with this coding and modulation scheme MCS i^* , which will form the multicast group MG_i^* , (203, 204), calculate
- 20 the bitrate $M(i^*)$ for each user with this coding and modulation scheme,
- For the users not having at their disposal capabilities to demodulate the messages coded with the scheme MCS i^* ,
- Construct a tree A composed of a set of links L which connect a mobile device UE_k not belonging to MG_i^* to one and only one mobile device UE_k
- 25 belonging to the group MG_i^* (206),
- Use an algorithm for allocating the resources on the links L thus defined (207),
- Evaluate the value of minimum bitrate $D(i^*)$ allocated on the links L of the tree A , save the minimum value $T(i^*)$ corresponding to the minimum bitrate between
- 30 $D(i^*)$ and the bitrate of the point-to-multipoint transmission $M(i^*)$,
- If the bitrate on the D2D links, $D(i^*)$, is greater than the bitrate of the point-to-multipoint transmission $M(i^*)$, the bitrate of the point-to-multipoint

transmission is retained as minimum bitrate therefore $T(i^*) = M(i^*)$, otherwise $T(i^*) = D(i^*)$,

- $D(i^*)$ represents the minimum bitrate on the links L of the tree A in the algorithm for allocating the resources (207),
- 5 • $T(i^*)$ is the minimum between the bitrate on the links of the tree $D(i^*)$ and the bitrate on the multicast links $M(i^*)$, $T(i^*) = \min(D(i^*), M(i^*))$, (208)

In the case where all the users belong to MG_i^* , then $T(i^*) = M(i^*)$, (209),

If the bitrate allocated to the present links for the maximum index of the modulation coding scheme $T(i^*)$ is greater than or equal to the allocated bitrate for the index T_{old} , (210):

- If the minimum bitrate allocated to the links $T(i^*) = M(i^*)$, the bitrate received at each user with the modulation and coding i^* , (211)
 - Save $T_{old} = T(i^*)$, pass to the modulation index $i^* = i^* + 1$, (212), and return to the step of constructing the group MG_i^* ,
- 15 ○ Otherwise, if $T(i^*) < M(i^*)$,:
 - Returning the value of MCS i^* and $Alloc_D2D(i^*)$, (213),

Otherwise, $T(i^*)$ is less than T_{old} , return the value of MCS $i^* - 1$, (214) and its D2D allocation, $Alloc_D2D(i^* - 1)$,

20 Allocate radio resources on the D2D connections defined by the tree A .

13 – The system as claimed in claim 12, wherein the processor is implemented at the level of a base station of the communication network.

25 14 – The system as claimed in claim 12, wherein the processor is implemented at the level of an application server dedicated to the management of the group communications.