(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 October 2011 (06.10.2011)

PCT

(10) International Publication Number
WO 2011/121444 A2

(51) International Patent Classification:
H04W 72/08 (2009.01)

(21) International Application Number:
PCT/IB2011/000931

(22) International Filing Date:
30 March 2011 (30.03.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PCT/CN2010/071437 30 March 2010 (30.03.2010) CN

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

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(54) Title: RESOURCE ALLOCATION METHOD AND SYSTEM

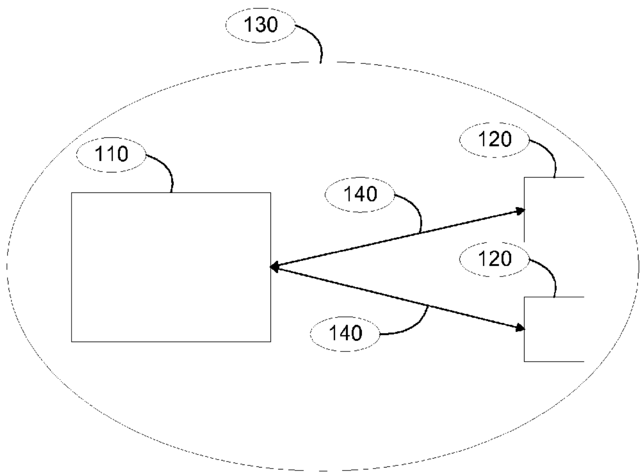

Figure 1

(57) Abstract: A method for allocating resources in a telecommunication network to at least one user equipment in a plurality of user equipments, each of said user equipments being operable to communicate in said telecommunication network with a base station, said method, comprising, for said base station, the acts of obtaining, for each user equipment, a channel estimator of a channel for communicating with said user equipment in a set of channel estimators among a plurality of sets of channel estimators; calculating, for each sub-set of at least one user equipment obtainable from at least one set of user equipments having selected a channel estimator in a same set of channel estimators, a throughput corresponding to an estimation of the bandwidth consumption of the sub-set of user equipments in the telecommunication network; allocating the resources to the sub-set of user equipments corresponding to the maximum calculated throughput.

WO 2011/121444 A2

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

RESOURCE ALLOCATION METHOD AND SYSTEM

Field of the Invention

The present invention relates in general to telecommunication networks and more specifically to resource allocation in a telecommunication network.

Background of the Invention

The International Telecommunications Union (ITU) has been defining a framework for telecommunication development called International Mobile Telecommunications Advanced (IMT Advanced). The requirements of IMT Advanced wireless systems involve high spectrum efficiency in order to achieve communication data rates of 1 Gbit/s and above in telecommunication networks. The Third Generation Partnership Project (3GPP) aims, through its Long Term Evolution (LTE)-Advanced group, at defining telecommunication standards that match the IMT Advanced framework. In particular, enhanced multi-carrier based Multiple Input Multiple Output (MIMO) systems which have been defined by the 3GPP will be key solutions to achieve those targets.

3GPP has been defining standards for transmitters and receivers in telecommunication networks. In particular, 3GPP LTE standards have defined the use of 4 transmitting antennas per transmitter called node B (i.e. the Base Station as defined in 3GPP standards). However, a higher number of antennas may be used. Indeed, as there is more flexibility to use multiple antennas at the node B than at the receiver or user equipment (UE) side, then, for example, up to 8 or 12 antennas may thus be considered at node B while the user equipment may be equipped e.g. with 4 antennas. Using significantly more antennas at the node B than at the user equipment implies the use of Multiple-Users Multiple Input Multiple Output (MU-MIMO) systems, wherein the receiving antennas may be distributed over multiple user equipments. In MU-MIMO, multiple users may be served at the same time on the same sub-carrier by means of spatial separation. Separation of users may also be performed using for instance Time-Division Multiple Access (TDMA) (temporal separation) and Frequency-Division Multiple Access (FDMA) (frequency separation), but also using e.g. Spatial-Division Multiple Access (SDMA) (spatial separation) provided that the actual spatial separation of the user equipments is sufficient. This technique attempts to increase the system capacity by intelligently allocating a communication channel to different subgroups of user equipments.

In the most general form of MU-MIMO transmission scheme, one or more parallel spatial streams are independently Forward Error Correction (FEC) coded and then mapped to one or more transmission layers of a communication channel. The number of transmission layers is typically less than or equal to the number of physical antennas. The process of converting the transmission layers to the signal on the real antennas is typically done by linear precoding (i.e. linearly combining the virtual antenna signals to obtain the actual transmit signals).

Codebook based precoding is deployed in the current LTE downlink MU-MIMO standards. To determine the users being served simultaneously in the next frame, a solution is described in WO 2009/026768 "Wireless communication system and wireless communication method", ZHANG Jie and ZHOU Hua. In this solution, the node B first chooses, among the user equipments it communicates with, the user equipment with the associated largest Channel Quality Indicator (CQI) value. The CQI is an indicator of the quality of the channel between the node B and the user equipment calculated by the user equipment and fed back or sent to the node B by the user equipment. The CQI is then used to calculate a given metric (e.g. throughput). Once the user equipment corresponding to the largest CQI value has been selected and the corresponding metric has been calculated, the metric corresponding to the combination of said first selected user equipment and a second user equipment within the same set of user equipments is calculated. A set of user equipments is defined as being the user equipments having the same codebook index. The codebook index indicates the line in a codebook wherein each column vector component is orthogonal to other column vector component in said line two by two. The codebook is defined in 3GPP standards as being a precoding matrix comprising column vectors representing precoding vector. An identical codebook is stored on both node B and each user equipment so that a user equipment may indicate to the node B which line and column of the codebook contains the precoding vector that is the best weighting factor (or quantization estimated channel vector between the Node B and a given user equipment) to further estimate at best the channel as perceived by the user equipment. In the existing solution, if the metric of the combination of the first and second user equipments is greater than the metric of the first user equipment alone, then a third user equipment of the same set of user equipments is used to calculate the metric of the combination of the first, second and third user equipments otherwise the process is stopped and only the first selected user equipment will be allocated resources. In other words, this process is repeated until the n-th effective metric value is smaller than the (n-1)-th effective metric value. However a drawback of this solution is that the set of selected user equipments is not necessarily the optimum set of user equipments. Indeed, the metric for the combination of user equipments combined with the first user equipment selected having the maximum CQI is not necessarily the maximum metric among the given set of user equipments, not among all the sets of user equipments, as only one user equipment is selected based on the maximum CQI, but not the best combination of user equipment with the optimum metric.

Today there is no solution to efficiently allocate resources that allow reducing interferences and thus improving efficiency of such wireless telecommunication systems.

Today there is a need for an efficient resource allocation solution that can be easily implemented on the existing communication infrastructures.

Summary of Invention

It is an object of the present system to overcome disadvantages and/or make improvement over the prior art.

To that extend, the invention proposes a method for allocating resources to a plurality of telecommunication user equipments in a telecommunication network according to claim 1.

The method allows a Base Station allocating resources in a telecommunication network to at least one user equipment in a plurality of user equipments, wherein each of said user equipments is operable to communicate in said telecommunication network with the base station. The method, comprises, for said base station, the acts of:

- obtaining, for each user equipment, a channel estimator of a channel for communicating with said user equipment in a set of channel estimators among a plurality of sets of channel estimators,
- calculating, for each sub-set of at least one user equipment obtainable from at least one set of user equipments having selected a channel estimator in a same set of channel estimators, a throughput corresponding to an estimation of the bandwidth consumption of the sub-set of user equipments in the telecommunication network,
- allocating the resources to the sub-set of user equipments corresponding to the maximum calculated throughput.

An advantage of the invention according to claim 1 is that the set of user equipments that is scheduled for resource allocation is selected among all the sets of user equipments and not only on a maximum metric for a single user equipment.

In an embodiment of the invention, channel estimators in the same set of channel estimators are mutually orthogonal. This allows selecting and allocating resources to the set of user equipment with the maximum metric and ensures at the same time the user equipment to be scheduled using orthogonal vector components, avoiding thus interferences and increasing the system efficiency while taking the optimum use of resource allocation for the system.

The invention also proposes a Base Station according to claim 6.

The invention also proposes a system according to claim 11.

The invention also proposes a readable computer program according to claim 12.

Brief Description of the Drawings

Embodiments of the present invention will now be described solely by way of example and only with reference to the accompanying drawings, where like parts are provided with corresponding reference numerals, and in which:

Figure 1 schematically illustrates a system according to an embodiment of the present invention;

Figure 2 schematically illustrates a method according to a first embodiment of the present invention;

Figure 3 schematically illustrates a method according to a second embodiment of the present invention;

Figure 4 schematically illustrates a performance simulation according to an embodiment of the present invention.

Description of Preferred Embodiments

The following are descriptions of exemplary embodiments that when taken in conjunction with the drawings will demonstrate the above noted features and advantages, and introduce further ones.

In the following description, for purposes of explanation rather than limitation, specific details are set forth such as architecture, interfaces, techniques, devices etc..., for illustration. However, it will be apparent to those of ordinary skill in the art that other embodiments that depart from these details would still be understood to be within the scope of the appended claims.

Moreover, for the purpose of clarity, detailed descriptions of well-known devices, systems, and methods are omitted so as not to obscure the description of the present system. Furthermore, routers, servers, nodes, gateways or other entities in a telecommunication network are not detailed as their implementation is beyond the scope of the present system and method.

Unless specified otherwise, the exemplary embodiment will be described hereafter in its application to a base station of a wireless telecommunication network.

In addition, it should be expressly understood that the drawings are included for illustrative purposes and do not represent the scope of the present system.

Figure 1 describes an illustrative embodiment of the system according to the invention.

A Base Station 110, like for example a node B, communicates with user equipments 120 in a telecommunication network 130. The base station 110 is equipped with a memory or a computer readable medium for storing a computer program comprising program instructions and a processor for executing this computer program, so as to implement the acts of the methods according to the invention, in particular those acts which are described here after by reference to Figures 2 and 3.

In order to allocate resources to the user equipments 120, the Base Station 110 obtains some information from user equipments 120 in the telecommunication network 130. This information comprises:

- an indication allowing identifying a set of estimators in a group of sets of estimators and,

- an indication allowing identifying an estimator of the channel between the base station and a user equipment in said set of estimators.

An estimator of a channel of a user equipment (i.e. channel estimator) corresponds to a vector allowing estimating the channel between the base station and a user equipment, such as e.g. a precoding vector. As the channel between the Node B and a user equipment may be represented or materialized by a channel matrix, the product of the channel matrix and the channel estimator (e.g. precoding vector) represents the estimated channel as perceived by the user equipment.

Figure 2 describes an illustrative embodiment of the method according to the invention. The method according to the invention allows, for a Base Station 110, allocating resources in a telecommunication network 130 to at least one user equipment 120 among a plurality of user equipments. Each of said user equipments may be operable to communicate in the telecommunication network 130 with the Base Station 110. The Base Station 110 obtains, in an act 210, for each user equipment, a channel estimator. Said channel estimator is an estimator of a channel for communicating with said user equipment 120. The channel estimator belongs to a set of channel estimators among a plurality of sets of channel estimators. In act 220, the

Base Station 130 calculates, for each sub-set of at least one user equipment 120 obtainable from at least one set of user equipments having selected a channel estimator in a same set of channel estimators, a throughput corresponding to an estimation of the bandwidth consumption of the sub-set of user equipments in the telecommunication network 130. In other word, a throughput is calculated for each of all the combinations of user equipments having selected a channel estimator in a same set of channel estimators. In act 230, the Base Station 110 allocates the resources to the sub-set of user equipments corresponding to the maximum calculated throughput.

In an illustrative embodiment of the method according to the invention, the act 220 of calculating the throughput may be performed using the corresponding obtained channel estimators, as described here under in equations (5) to (8) in reference to Figure 4.

In an illustrative embodiment of the method according to the invention, the act 220 of calculating the throughput may be performed for each set of user equipments having selected a channel estimator in a same set of channel estimators. Indeed, by doing so, a metric is derived in order to allow optionally further comparison of said metric among different sets of user equipments.

In an illustrative embodiment of the method according to the invention, channel estimators in the same set of channel estimators may be mutually orthogonal. For example, in 3GPP standards, a codebook of channel estimators is defined in the form of a matrix, each component of which representing a channel estimator (or precoding vector), such that the column vectors of said codebook matrix are orthogonal two by two. This means that on the same matrix line, vector components are orthogonal two by two: this avoids interferences for user equipments scheduled with channel estimators of the same matrix line of the codebook. In an embodiment of the invention, each set of channel estimators is composed with channel estimators that are mutually orthogonal. A set of channel estimators may thus be defined as corresponding to a line of the matrix.

In an illustrative embodiment of the method according to the invention, the method may further comprise, before act 230 and after act 220, an act 225 of selecting, said act of selecting comprising selecting the maximum throughput among the maximum calculated throughputs in each set of channel estimators or selecting the maximum throughput among all the calculated throughputs for each of all the combinations of user equipments. Indeed, according to an illustrative embodiment of the method according to the invention, the maximum throughput may be derived for each set of user equipments and therefore the maximum throughput among all the sets of user equipments may consequently be derived.

In an illustrative embodiment of the method according to the invention, the channel estimator may be identified in a matrix of channel estimators by a first index and a second index received from said user equipment, said first index identifying a sub-set of channel estimators in said plurality of sub-sets of channel estimators, said second index identifying a channel estimator in said identified sub-set of channel estimators. The first index may be a line index of the matrix and the second index may be a column index of the matrix. Said matrix may correspond to a codebook of channel estimators.

Figure 3 describes an illustrative embodiment of the method according to the invention in a Multiple-User Multiple Input Multiple Output (MU-MIMO) system.

In a MU-MIMO system, the Base Station 110 communicates with a user equipment 120 during transmission periods of time on a channel comprising physical paths or beams. Channel estimators of the channel between the Base Station 110 and a user equipment 120 may be stored in a codebook. The codebook is then stored in each user equipment 120 and the Base Station 110 of the telecommunication network 130. This allows the Base Station 130 and the user equipments 120 to have as a reference the same channel estimators in the same codebook. When channel estimators are stored in a codebook as a matrix, only a line number and a column number are needed to identify a channel estimator in the codebook. Therefore, when a user equipment 120 has estimated the channel (for example on the downlink path from the Base Station 110 using e.g. reference signals), it may then decide which channel estimator of the codebook represents or estimate at best (i.e. is the most similar or representative of) said channel. Consequently, the user equipment 120 may only need sending the line and column number to the Base Station 110 for the Base Station 110 to know which channel estimator in its codebook it refers to. This information may be sent as a codebook vector comprising the column number as a column vector index or Rank Index (RI) and the line number as a line index or Precoding Matrix Index (PMI) as commonly named in 3GPP standards. In the description here under, the Base Station 110 is materialized by a Node B (or eNode-B) as referred to in 3GPP standards.

The procedure for codebook based MU-MIMO transmission may be described as follows:

- in a preliminary act 310, each user equipment 120 may estimate its channel (i.e. the channel between said user equipment 120 and the Base Station 110) according to, for instance, a common reference signal sent downlink by the Base Station 110 to user equipments 120 within the telecommunication network 130, then,
- in a preliminary act 320, each user equipment 120 may determine its preferred PMI and Rank Index (RI) (or column vector index) in the codebook according to the best matching channel estimator (or precoding vector) for estimating the channel as performed in act 310 and calculate a metric Channel Quality Indicator (CQI) like for example the Signal to Interference plus Noise Ratio (SINR) (without necessarily knowing the other user equipment beams),
- in an act 330, PMI and RI corresponding to the maximum Signal to Interference plus Noise Ratio may be reported by the user equipment 120 to the Node B 110 as well as the corresponding Signal to Interference plus Noise Ratio value,
- in an act 340, by acknowledging the PMI and RI indications received from each user equipment 120, the Node B 110 may schedule user equipments (i.e. select the user equipment(s) which will be allocated the resources) using the user equipment pairing scheme according to the invention as described in reference to act 220 of Figure 2 and in detail here under in reference to Figure 4,
- in a further act 350, each user equipment 120 may demodulate its own signals with or without the pairing users information indication comprised in the DownLink (DL) signaling.

Here below is described an illustrative embodiment of the method according to the invention in reference to act 340 of Figure 3.

In the method according to the invention, the throughput may be calculated (using e.g. the Signal to Interference plus Noise Ratio (SINR)) and compared to throughput of each other combinations of user equipments having the same Precoding Matrix Index (PMI) (or codebook line index) and orthogonal precoding vectors. The combination of user equipments 120 corresponding to the maximum throughput may be chosen as being the set of user equipments 120 that will be scheduled (i.e. selected for resource allocation) in the next transmission period of time.

A MU-MIMO system comprises a transmitter with M_t transmit antennas serving K users each equipped with M_r receive antennas. In this illustrative embodiment, the transmitter is a Node B 110 which may communicate with K users simultaneously on the same Time and Frequency resource unit.

For each user k, the received signal y_k may be expressed by:

$$y_k = h_k c_k x_k + \sum_{\substack{j=1 \\ j \neq k}}^{K} h_k c_j x_j + n_k \qquad (1)$$

wherein:

M_r is the number of receiving antennas

M_t is the number of transmitting antennas

$C^{m \times n}$ is a complex matrix of size (m x n)

$h_k \in C^{M_r \times M_t}$ is the channel matrix of user k materializing the channel between the Base Station and the user equipment,

$c_k \in C^{M_t \times 1}$ is the precoding vector (i.e. channel estimator) of user k

$h_k c_k$ is the estimated channel between the Base Station and user k quantized using channel estimator (or precoding vector) C_k

$x_k, x_j \in C^{1\times1}$ are the transmitted symbols to user k and user j

$n_k \in C^{M_r}$ is the white Gaussian noise vector.

The Channel Quality Indicator (CQI) (in this illustrative embodiment the Signal to Interference plus Noise Ratio (SINR)) may be calculated at the kth user equipment as follows:

- first, a channel estimation is performed using downlink reference signal sent by the Node B 110,
- with the channel matrix h_k materializing the channel between the Node B and user equipment k, the coefficient for a Minimum Mean Square Error (MMSE) receiver may be expressed as:

$$A_{mmse} = ((h_k \cdot c_k)^H \cdot R_n^{-1} \cdot (h_k \cdot c_k + I))^{-1} \cdot (h_k \cdot c_k)^H \cdot R_n^{-1} \qquad (2)$$

with

$$R_n = \sum_{j \neq k} h_k c_j \cdot (h_k c_j)^H + I \cdot \sigma^2 = h_k \cdot h_k^H - (h_k c_k) \cdot (h_k c_k)^H + I \cdot \sigma^2 \qquad (3)$$

wherein

- σ^2 is the variance of the white Gaussian noise,
- I is the identity matrix,
- $(.)^H$ is the transpose conjugate operation of matrix h_i (which is a kind of matrix operation).

Without knowing the other user's beam information, user k may calculate an estimation of a Signal to Interference plus Noise Ratio for a given precoding vector c_k, noted $SINR(c_k)$ as:

$$SINR(c_k) = \frac{\left|A_{mmse} h_k c_k\right|^2}{\left\|A_{mmse} h_k\right\|^2 - \left|A_{mmse} h_k c_k\right|^2 + \frac{M_t}{P}\left\|A_{mmse}\right\|^2} \qquad (4)$$

where P is the sum transmission power (i.e. the transmission power of the Node B as predefined in the 3GPP standards).

As described here above in reference to act 330 of Figure 3, the PMI and the Rank Index (RI) (i.e. the codebook column vector index) of precoding vector c_k corresponding to the maximal $SINR(c_k)$ (using equation (4)) will be feedback to the Node B, optionally along with the corresponding SINR as Channel Quality Indicator.

Indeed, each user equipment will feedback to the Node B, along with the PMI, the Rank Index (RI) of precoding vector c_k corresponding to the maximal SINR among the SINR calculated for each precoding vector c_k of the predefined codebook. Transmitting only the indexes from a user equipment to the Node B allows consuming less bandwidth than actually sending the actual precoding vector c_k corresponding to the maximum $SINR(c_k)$ among all the $SINR(c_k)$ for each precoding vector c_k. Once the Node B has received the PMI and the RI of precoding vector c_k corresponding to the maximal SINR, it may derive which precoding vector c_k, which represents the channel estimator as referred to in act 210 (in reference to Figure 2), has been determined by the user equipment in its codebook as both codebook at the user equipment and the Node B are the same.

$SINR(c_k)$ may also be further used by the Node B to determine which coding and modulation scheme will be used for each user equipment. A high $SINR(c_k)$ means that user k has a good channel condition, thus a high order modulation scheme may be allocated to it.

In this illustrative embodiment of the method according to the invention, the codebook of existing 3GPP LTE Release 8 is used as an example along with a MU-MIMO transmission system with 4 antennas at the transmitter end, at most 4 users being served simultaneously each equipped with 2 antennas and 1 stream served.

Table 1 below describes an illustrative embodiment of a codebook matrix with 16 lines and 4 columns, in which each matrix line in the table represents a Precoding Matrix Index (PMI) and a matrix column identifies a Rank Index (RI) of the precoding matrix. The PMI varies from 1 to 16 and the index of column vector belonging to each matrix varies from 1 to 4. These two indexes will be feedback to the Node B 110 by each user equipment 120.

Codebook Index	**Column vector of Rank 4**			
	1	2	3	4
1				
2	U2	U6	U1	U8
3				
4				
5				
6		U3		
7				
8		U7	U4	U5
9				
10				
11				
12				
13		U10	U9	
14				
15				
16				

Table 1: illustration of user pairings

At the Node B 110, upon receiving the precoding vector indexes feedback from each user equipment 120 as described in act 220 and act 330 (in reference respectively to Figure 2 and 3), the Node B 110 will fill out this table using the indexes of each user.

For example, when the preferred codebook vector of the 1st user is the 3rd column of the Precoding Matrix Index 2 (i.e. RI=3, PMI=2), U1 will be put on the 2nd line and 3rd column of the table. Also from the table it may be seen that U2 prefers (i.e. has estimated its channel estimator has matching the best) the first column of the precoding matrix with Precoding Matrix Index 2 (i.e. RI=1 and PMI=2). After all the user equipment indexes have been put into the table, the Node B 110 will calculate the throughput (using e.g. the SINR) of each combination of user equipments belonging to the same line, the columns of the assembled precoding matrix being orthogonal to each other. For example, in Table 1, U7, U4, U5 are lying on the same line, then the throughput of each combination {U7, U4, U5}, {U7, U4}, {U7, U5}, {U4, U5}, {U7}, {U4}, {U5} will be calculated respectively. The Node B 100 will then compare these throughput values and choose one pairing (i.e. combination) of user equipment(s) with the maximum throughput as being the one to schedule in the next transmission period of time. The sum throughput of user combination, as described in act 220 in reference to Figure 2, {Um,Un} may be calculated in an illustrative embodiment of the method according to the invention, as:

$$T_{sum} = \sum_{i=1}^{k} T_i = \sum_{i=1}^{k} \log_2(1 + SINR_i) \qquad (5)$$

where $SINR_i$ denotes the Signal to Interference plus Noise Ratio of user i by employing its preferred precoding vector while considering other users of each combination set as interference with:

$$SINR_i = \frac{\left|A_{mmse\_i} \cdot h_i \cdot c_i\right|^2}{\sum_{\substack{j=1 \\ j \neq i}}^{L} \left|A_{mmse\_i} \cdot h_i \cdot c_j\right|^2 + \frac{M_t}{P} \left\|A_{mmse\_i}\right\|^2 \cdot \sigma_n^2} \qquad (6)$$

Where:

$$A_{mmse\_i} = ((h_i \cdot c_i)^H \cdot R_n^{-1} \cdot (h_i \cdot c_i + I))^{-1} \cdot (h_i \cdot c_i)^H \cdot R_n^{-1} \qquad (7)$$

$$R_n = h_i \cdot h_i^H - (h_i c_i) \cdot (h_i c_i)^H + (\frac{M_t}{P}) \cdot I \cdot \sigma^2 \qquad (8)$$

Wherein:

- A_{mmse_i} is the filter coefficient at the receiver of user i, this value may be calculated at the Node B or feedback to the Node B by each user equipment,
- h_i represents the channel matrix of user i
- c_i is the (preferred) precoding vector (i.e. channel estimator) of user i,
- M_t is the number of transmitting antenna at the Node B,
- σ^2 is the variance of the white Gaussian noise,
- $(\cdot)^H$ is the transpose conjugate operation,
- P is the total transmission power at the Node B as predefined in the 3GPP standards,
- integer j varies in this example from 1 to L, L is the number of users in each combination set except user i itself (for example, it may be typically L=4 such as currently defined in the 3GPP standards)
- I is the identity matrix
- R_n represents the covariance of interferences and noise.

In the method according to the invention therefore, the maximum throughput is calculated for all the combinations of user equipments in the same line of the codebook then the maximum of the maximum throughputs of all the lines of the codebook may be selected so that user equipments of the corresponding line may be allocated resources in priority (for example in the next period of time for communicating data on the downlink from the Node B to said selected user equipments), as described in act 230 in reference to Figure 2.

Figure 4 describes the performance of the method according to the invention using throughput as a metric. To make a comparison, the performance of the existing solution is also displayed on Figure 4.

In this simulation, the number of users in a cell is equal to 10. It may be seen from this figure that increase in throughput may be obtained by using the proposed user pairing scheme. Furthermore, similar results may be obtained when the number of user equipments in a cell increases to 20 and 30. The simulation parameters are shown in Table 2 here under:

Parameter	**Baseline Assumptions**
Transmit Antennas	4
Receiver Antennas	2
Maximum number of users being scheduled simultaneously	4
Modulation scheme	QPSK
Channel	Random channel matrix(i.i.d Gaussian entries with unit variance)
Codebook	LTE
Receiver	MMSE

Table 2: simulation parameters

CLAIMS

1. A method for allocating resources in a telecommunication network to at least one user equipment in a plurality of user equipments, each of said user equipments being operable to communicate in said telecommunication network with a base station, said method, comprising, for said base station, the acts of:
- obtaining, for each user equipment, a channel estimator of a channel for communicating with said user equipment in a set of channel estimators among a plurality of sets of channel estimators,
- calculating, for each sub-set of at least one user equipment obtainable from at least one set of user equipments having selected a channel estimator in a same set of channel estimators, a throughput corresponding to an estimation of the bandwidth consumption of the sub-set of user equipments in the telecommunication network,
- allocating the resources to the sub-set of user equipments corresponding to the maximum calculated throughput.

2. A method according to claim 1, wherein the act of calculating the throughput is performed using the corresponding obtained channel estimators.

3. A method according to any of the preceding claims, wherein the act of calculating the throughput is performed for each set of user equipments having selected a channel estimator in a same set of channel estimators.

4. A method according to any of the preceding claims, wherein channel estimators in the same set of channel estimators are mutually orthogonal.

5. A method according to any of the preceding claims, wherein the channel estimator is identified in a matrix of channel estimators by a first index and a second index received from said user equipment, said first index identifying a sub-set of channel estimators in said plurality of sub-sets of

channel estimators, said second index identifying a channel estimator in said identified sub-set of channel estimators.

6. A base station for allocating resources in a telecommunication network to at least one user equipment in a plurality of user equipments, each of said user equipments being operable to communicate in said telecommunication network with the base station, the base station being operable to:
- obtain, for each user equipment, a channel estimator of a channel for communicating with said user equipment in a set of channel estimators among a plurality of sets of channel estimators,
- calculate, for each sub-set of at least one user equipment obtainable from at least one set of user equipments having selected a channel estimator in a same set of channel estimators, a throughput corresponding to an estimation of the bandwidth consumption of the sub-set of user equipments in the telecommunication network,
- allocate the resources to the sub-set of user equipments corresponding to the maximum calculated throughput.

7. A base station according to claim 6, wherein the throughput is calculated using the corresponding obtained channel estimators.

8. A base station according to any of the preceding claims 6 or 7, wherein the throughput is calculated for each set of user equipments having selected a channel estimator in a same set of channel estimators.

9. A base station according to any of the preceding claims 6 to 8, wherein channel estimators in the same set of channel estimators are mutually orthogonal.

10. A base station according to any of the preceding claims 6 to 9, wherein the channel estimator is identified in a matrix of channel estimators by a first index and a second index received from said user equipment, said first index identifying a sub-set of channel estimators in said plurality of sub-sets of

channel estimators, said second index identifying a channel estimator in said identified sub-set of channel estimators.

11. A system for allocating resources in a telecommunication network to at least one user equipment in a plurality of user equipments, said system comprising:

- a telecommunication network,
- a base station according to claim 6
- a plurality of user equipments, wherein each of said user equipments is operable to communicate in the telecommunication network with the base station.

12. A computer-readable medium having computer instructions to enable a computer system to perform the method of any one of claims 1 to 5.

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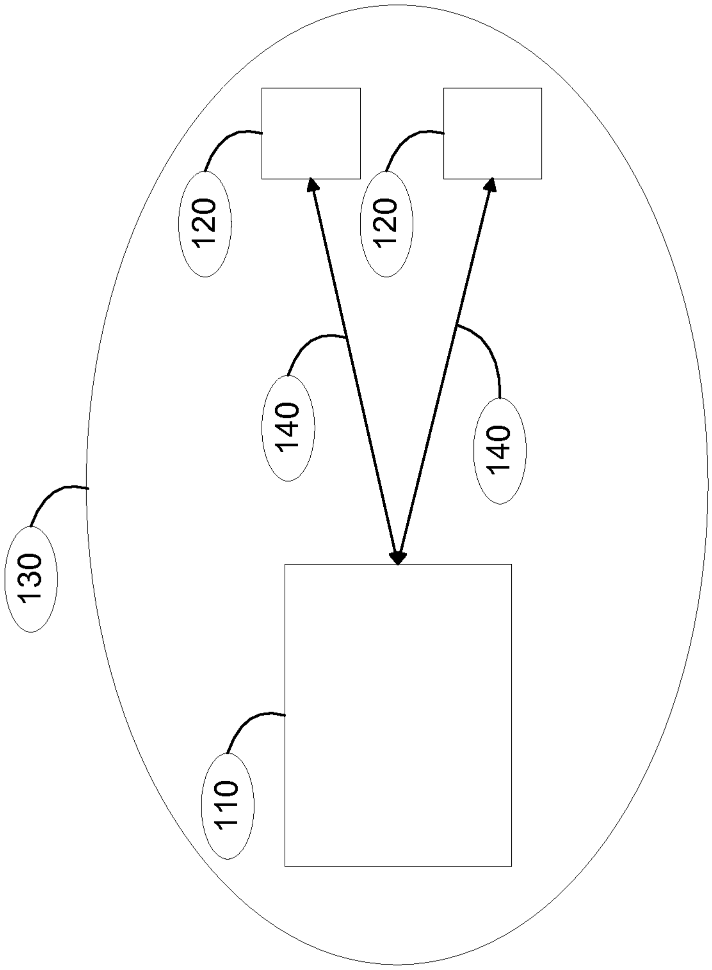

Figure 1

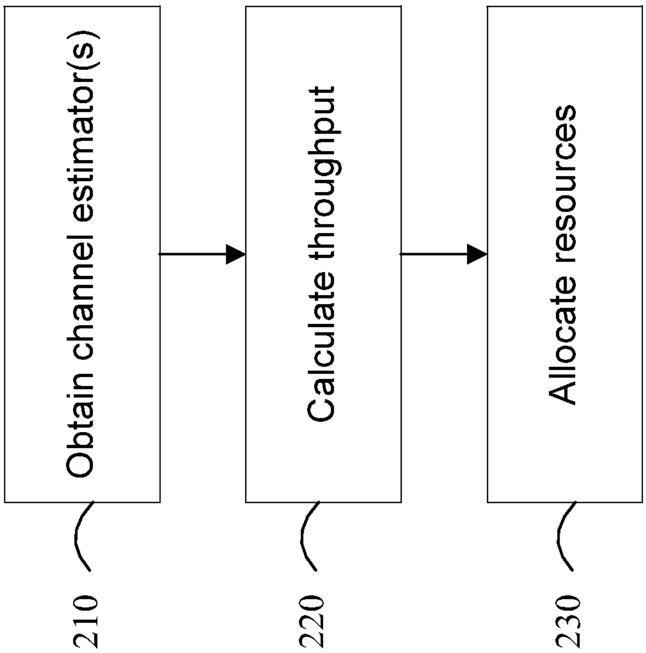
Obtain channel estimator(s)
Calculate throughput
Allocate resources
210
220
230

Figure 2

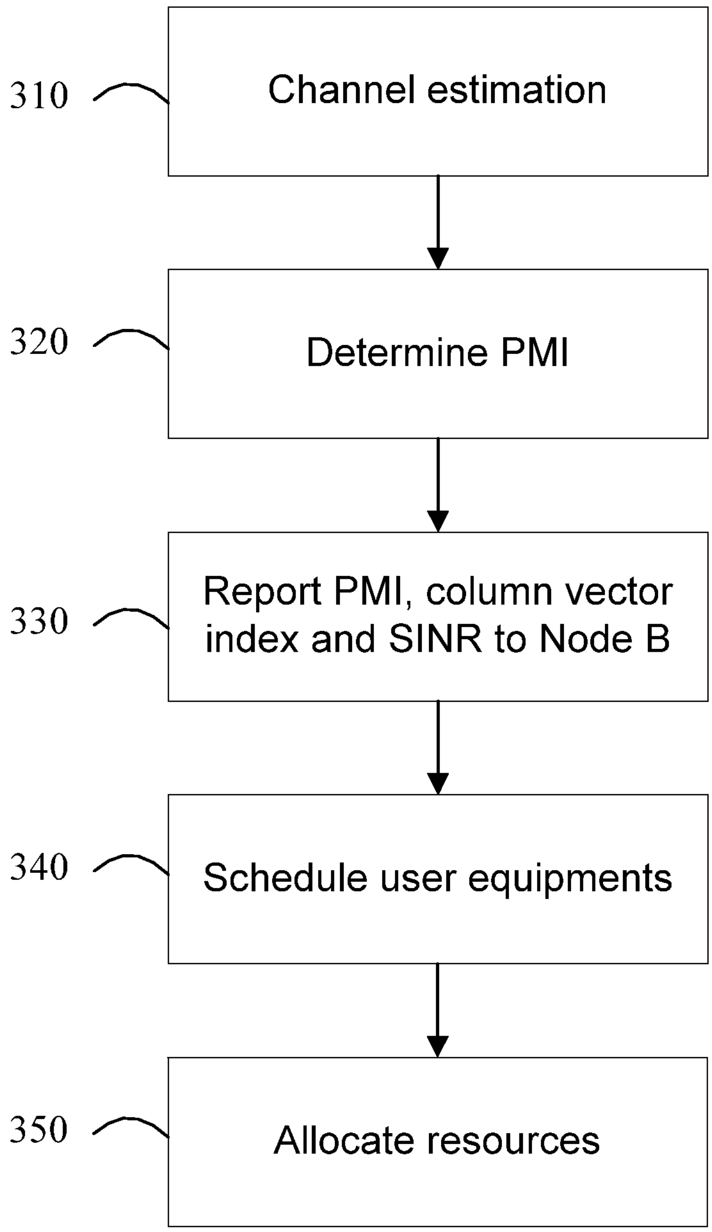
310
Channel estimation
320
Determine PMI
330
Report PMI, column vector index and SINR to Node B
340
Schedule user equipments
350
Allocate resources

Figure 3

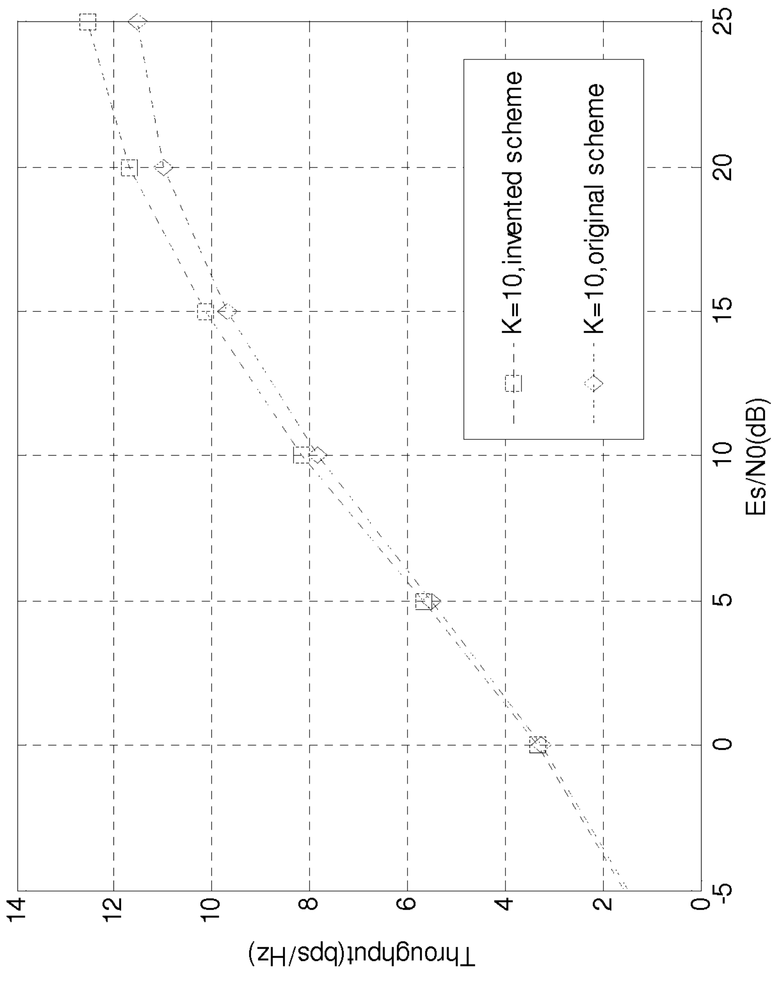
Throughput(bps/Hz)
Es/N0(dB)
K=10,invented scheme
K=10,original scheme
0
2
4
6
8
10
12
14
-5
0
5
10
15
20
25

Figure 4