



(51) International Patent Classification:

H04L 25/03 (2006.01) *H04B 7/08* (2006.01)
H04L 5/14 (2006.01) *H04B 7/04* (2006.01)
H04B 7/06 (2006.01)

(21) International Application Number:

PCT/EP2015/053489

(22) International Filing Date:

19 February 2015 (19.02.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: NOKIA SOLUTIONS AND NETWORKS
OY [FI/FI]; Karaportti 3, FIN-02610 Espoo (FI).(72) Inventors: TÖLLI, Antti; Kurkiojantie 19, FIN-90650
Oulu (FI). TIIROLA, Esa Tapani; Porttikellonkuja 12,
FIN-90450 Kempele (FI). PAJUKOSKI, Kari Pekka;
Purantie 3, FIN-90240 Oulu (FI).(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, BN, 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, IR, IS, JP, KE, KG, KN, KP, KR,
 KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
 MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
 PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, RW, SD, SL, ST, SZ,
 TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: PRE-CODING

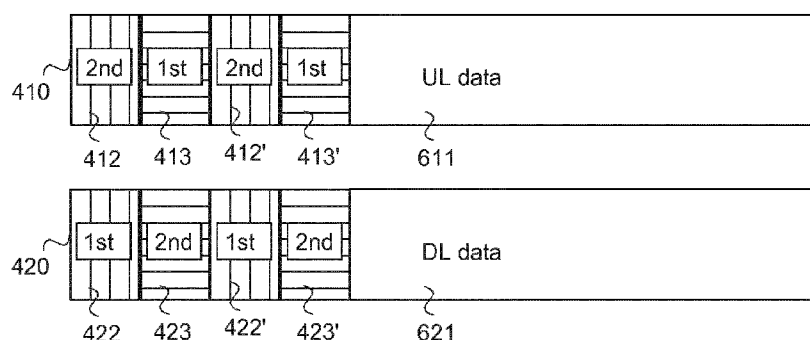


FIG.4

(57) Abstract: A pre-coding adaptation process includes one or more pre-coded reference signal exchange between an apparatus using a first resource type for a first pre-coded reference signal and a user device using a second resource type for a second pre-coded reference signal. For example, if the link direction is up-link, the first resource type may be a backward phase and the second resource type is a forward phase, and if the link direction is downlink, the first resource type may be a forward phase and the second resource type is a backward phase.

DESCRIPTION**TITLE****PRE-CODING****TECHNICAL FIELD**

The invention relates to communications.

BACKGROUND

The following description of background art may include insights, discoveries, understandings or disclosures, or associations together with disclosures not known to the relevant art prior to the present invention but provided by the invention. Some such contributions of the invention may be specifically pointed out below, whereas other such contributions of the invention will be apparent from their context.

In recent years, the phenomenal growth of mobile Internet services and proliferation of smart phones and tablets has increased use of mobile broadband services, and hence use of available spectrum. The air interface capacity may be increased through spatial reuse of spectrum, for example by using small cells with short range to complement the traditional macro/micro cell coverage.

Pre-coding is typically seen as a generalization of beamforming to support multi-stream (or multi-layer) transmission in multi-antenna wireless communications. Processing data streams before transmission by a pre-coding matrix chosen or adapted based on channel information improves especially the performance of a multi-antenna system.

BRIEF DESCRIPTION

According to an aspect, there is provided the subject matter of the independent claims. Embodiments are defined in the dependent claims.

BRIEF DESCRIPTION OF DRAWINGS

In the following, the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 shows simplified architecture of a system and block diagrams of some apparatuses according to an exemplifying embodiment;

Figure 2 illustrates a sub-frame structure;

Figures 3, 5, 6 and 7 are flow charts illustrating exemplary functionalities;

Figure 4 illustrates exemplary frame structures; and

Figures 8 and 9 are schematic block diagrams.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

The following embodiments are exemplifying. Although the specification may refer to “an”, “one”, or “some” embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments.

The present invention is applicable to any network/system configured to support time-division duplexing, or a corresponding asymmetric dynamic bidirectional transmission mechanism, and entities/nodes/apparatuses in such a network/system. Examples of such networks/systems include Long Term Evolution Advanced (LTE-A) access system, Worldwide Interoperability for Microwave Access (WiMAX), LTE Advanced, 4G (fourth generation) and beyond, such as and 5G (fifth generation), cloud networks using Internet Protocol, mesh networks, and ad-hoc networks, such as LTE direct and mobile ad-hoc network (MANET), peer-to-peer networking systems, like Internet of Things systems, wireless sensor network systems, or any combination thereof. The specifications of different systems and networks, especially in wireless communication, develop rapidly. Such development may require extra changes to an embodiment. Therefore, all words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, the embodiment. For example, future networks will most probably utilize network functions virtualization (NFV) which is a network architecture concept that proposes virtualizing network node functions into “building blocks” or entities that may be operationally dynamically instantiated, connected or linked together to provide network services. A virtualized network function (VNF) may comprise one or more virtual machines that run computer program codes using standard or general type servers instead of customized hardware. In other words, the concept proposes to consolidate many network equipment (apparatus, node) types onto standard servers whose hardware can run computer program codes implementing network functions, without a need for installation of new equipment. Cloud computing and/or data storage may also be utilized. In radio communications this may mean node operations to be carried out, at least partly, in a server, host or node operationally coupled to a remote radio head. It is also possible that node operations will be distributed amongst a plurality of servers, nodes or hosts. Another networking paradigm is software-defined networking (SDN) in which lower-level functionality is abstracted by decoupling data forwarding (data plane) from overlying control decisions, such as routing and resource allocations. This is achieved by means of one or more software-based SDN controllers that allow the underlying network to be programmable via the SDN controllers independent of underlying network hardware. Hence, it should be understood that the distribution of labor between core network operations and access network operations, such as base station operations, and user devices may differ from that of the LTE-A, or even be non-existent, and the below described base station functionality may be migrated to any corresponding abstraction or apparatus.

An extremely general architecture of an exemplifying system 100 is illustrated

in Figure 1. Figure 1 is a simplified system architecture only showing some elements and functional entities, all being logical units whose implementation may differ from what is shown. It is apparent to a person skilled in the art that the system comprises other functions and structures that are not illustrated, for example connections to the core network/system.

In the embodiment illustrated in Figure 1, the system 100 comprises a wireless access network (not illustrated in Figure 1) providing access to the system for user devices 110 (UE, user equipment, only one shown in Figure 1) by means of access point nodes 120 (only one shown in Figure 1), wherein an access point may be connected to one or more other network nodes and/or access nodes and/or to other networks 130, such as Internet, either via a core network or directly.

The user device 110 refers to a portable computing device (equipment, apparatus), and it may also be referred to as a user terminal or mobile terminal or a machine-type-communication (MTC) device, also called Machine-to-Machine device and peer-to-peer device. Such computing devices (apparatuses) include wireless mobile communication devices operating with or without a subscriber identification module (SIM) in hardware or in software, including, but not limited to, the following types of devices: mobile phone, smart-phone, personal digital assistant (PDA), handset, laptop and/or touch screen computer, e-reading device, tablet, game console, notebook, multimedia device, sensor, actuator, video camera, car, refrigerator, other domestic appliances, telemetry appliances, and telemonitoring appliances. The user device 110 is configured to support iterative pre-coder adaptation for decentralized dynamic bidirectional transmission. For that purpose the user device 110 may comprise an enhanced pre-coder unit (e-p-c-u) 111. An example of the functionality of the enhanced pre-coder will be described in more detail below. It should be appreciated that the user device 110 is depicted to include 2 antennas only for the sake of clarity. The number of reception and/or transmission antennas may naturally vary according to a current implementation.

The access point node 120, or any corresponding network entity (network apparatus, network node, network equipment) is an apparatus providing over-the-air access, including resource allocation, to a network (wireless or wired) 130 the access point is connected to, and the access point node may be configured to support one or more wireless access. Examples of such apparatuses include an evolved node B and a base station or any other access node. The access node 120 is configured to support access modes based on iterative pre-coder adaptation for decentralized dynamic bidirectional transmission. For that purpose the access node may comprise a pre-coder adaptation unit (p-c-a-u) 121. An example of the functionality of the pre-coder will be described in more detail below. It should be appreciated that the access node may have any number of reception and/or transmission antennas (not shown in Figure 1).

In the following, embodiments for pre-coding are discussed in further detail.

In wireless systems, such as a radio system, small cells with short range can

be used in addition to traditional macro/micro-cell coverage in order to satisfy the increase in demand of mobile traffic. In small cell scenarios, the amount of instantaneous uplink (UL) and downlink (DL) traffic may vary significantly with time and among the adjacent cells. For example, one cell may operate mostly in UL phase while adjacent cell(s) are operating mostly DL phase at a given time instant. Therefore, by dynamic allocation of uplink and downlink resources, such as allocating time-division-duplex (TDD) frames either to UL or DL usage depending on the instantaneous traffic load of the cell, may enhance the resource usage.

One example of a suitable frame structure is depicted in Figure 2. In the illustrated example, the frame 200 is a sub-frame that comprises a control portion 210 with a downlink portion 211 and an uplink portion 212, and a traffic portion 220. The traffic portion 220 is either for uplink traffic or for downlink traffic, depending on the operation mode. The sub-frame may correspond to a minimum scheduling unit in time. For example, the sub-frame structure may be implemented as a transmission time interval (TTI) sub-frame in TDD, for example

Pre-coding is typically seen as a generalization of beamforming to support multi-stream (or multi-layer) transmission in multi-antenna wireless communications. Processing data streams before transmission by a pre-coding matrix chosen or adapted based on channel information improves especially the performance of a multi-antenna system. Pre-coding can be considered as adapting the signal to be transmitted to the eigenstructure of the channel based on information obtained from the channel. Several pre-coding schemes are known, such as zero-forcing beamforming and singular value decomposition (SVD). The pre-coding adaptation procedure discussed in further details below may be carried out per each transmission frame or sub-frame in a way that receivers, optimized or adapted in a previous iteration, are used as pre-coders for a next transmission. Another option is to use implicit user selection for each frame by letting the iterative algorithm to decide on the set of users/streams to be served at a given time instant.

One embodiment starts in block 300 of Figure 3. This embodiment may be carried out by an access node or another network node or the pre-coder adaptation unit.

In block 302, a first pre-coding matrix, a plurality of resource types and a link direction are determined.

The first pre-coding matrix may be a pre-coding matrix last used (such as used for a previous data transmission or used in a previous frame), a pre-coding matrix chosen randomly or a predefined initial pre-coding matrix. It should be appreciated that "matrix" also comprises $1 \times m$ or $m \times 1$ matrix or a row or column vector (m is an integer ≥ 1).

The link direction is either from the access node to a user device, or from a user device to the access node. Usually, the link from a user device to an access node is called uplink or reverse link and the link from the access node to the user device is called downlink or forward link. Below terms "uplink", "UL" and "downlink", "DL" are used, without restricting the examples to such a terminology. As presented above, uplink and downlink

resources, such as time-division-duplex (TDD) frames, may be dynamically (not statically) allocated either to UL or DL usage depending on the instantaneous traffic load of the cell. The access node is aware of the traffic load and resource allocation. For example, if the traffic load for uplink direction is higher than for downlink direction, and/or near to the resource limit of the uplink direction or even over the resource limit, a resource typically used for downlink traffic may be allocated to an uplink transmission.

Resource types may be a forward phase and a backward phase or reverse phase as expressed by terms used in routing traffic or in radio communication meaning the direction of the traffic (forward towards a user device, backward or reverse towards an access node (or vice versa), for example).

In block 304, a first resource type for a first reference signal from the plurality of resource types is selected based on the link direction, the first resource type being in proportion to the link direction. For example, if the link direction is uplink, the first resource type is a backward phase, and if the link direction is downlink, the first resource type is a forward phase.

In block 306, the first reference signal is pre-coded by using the first pre-coding matrix and transmitted to a user device the pre-coded first reference signal using the first resource type.

Pre-coding may be carried out by multiplying the signal before transmission by a pre-coding matrix. Pre-coding is discussed above.

The first reference signal may be a pilot signal, a sounding reference signal (SRS), a channel state information reference signal (CSI-RS), or any other signal suitable for channel estimation. Such a signal is a kind of a training sequence, in other words a known signal transmitted for channel matrix estimation purposes. For example, in long term evolution (LTE) time division duplex (TDD) systems, node Bs use uplink sounding reference signals (SRSs) to estimate downlink channel state information (CSI) for downlink beamforming transmissions.

In block 308, a second pre-coded reference signal is received from the user device, the second pre-coded reference signal using a second resource type from the plurality of resource types and being pre-coded by using a second pre-coding matrix. For example, if the link direction is uplink, the second resource type is a forward phase, and if the link direction is downlink, the second resource type is a backward phase.

The second pre-coding matrix is formed by the user device, as will be described below.

The second reference signal may be a pilot signal, channel state information reference signal (CSI-RS), sounding reference signal (SRS) or any other signal suitable for channel estimation.

An example of the resource arrangement is shown in Figure 4. Figure 4 illustrates exemplary frame structures in an uplink cell and in a downlink cell. A frame may mean a time period during which the link direction is in use. A frame may comprise several

sub-frames.

Referring to Figure 4, the uplink cell frame 410 and the downlink cell frame 420 each comprises a bi-directional adjustment portion and a unidirectional data portion (traffic portion) 411, 421. The adjustment portion and the data portion each may comprise any amount of sub-frames. Hence, the uplink cell frame 410 and the downlink cell frame 420 may consist of plurality of sub-frames. In the illustrated example, the adjustment portion comprises two forward phases 412, 412', 422, 422', denoted by vertically hatched area, and two backward phases 413, 413', 423, 423', denoted by horizontally hatched area. The adjustment portion is for updating or adapting pre-coding matrixes, and the number of forward phases and backward phases depends on implementation details of the updating or adapting, described below.

For example, if the link direction is uplink, the first resource type for the adjusting procedure is a backward phase and the second resource type is a forward phase, and if the link direction is downlink, the first resource type is a forward phase and the second resource type is a backward phase. In other words, pre-coders from the user device in the uplink cells are transmitted at the same phase as pre-coders from the base station in the downlink cells, and pre-coders from the user device in the downlink cells are transmitted at the same phase as pre-coders from the base station in the uplink cells. By doing so, for example a coordinated transceiver (Tx) – receiver (Rx) processing in dynamic TDD setting in a decentralized manner is enabled.

Returning back to the process described in Figure 3, in block 310, the first pre-coding matrix is updated based on the received second pre-coded reference signal.

The first pre-coding matrix is usually updated based on a channel and/or interference conditions in the radio channel, wherein a channel is presented in a form of a matrix, typically denoted by H in mathematical expressions. The pre-coding matrix is designed to compensate the effects of the channel, such as scattering and fading. In practical systems, the compensation is normally partial affected also by a variable nature of a channel.

The embodiment ends in block 312.

An embodiment for updating or adapting a pre-coding matrix is now explained with reference to Figure 5. This procedure may be executed as a continuation of the embodiment described by means of Figure 3. In principle, the procedure is based on iteration: the updated first pre-coding matrix is transmitted (block 500) using the first resource type to the user device, an updated second pre-coding using the second resource type is received (block 502) from the user device, and the updating (block 504), transmitting and receiving are repeated until a predefined condition (block 506) is met. Several options for the predefined condition exist, for example the predefined condition may be a fixed number of repetition rounds, the number of repetition rounds is typically determined as a trade-off between time needed and wanted compensation accuracy. Another option is based on comparing the updated first pre-coding matrix and the updated second pre-coding matrix

and determining based on the comparison, whether to update the first updated pre-coding matrix. In this option, matrices may be compared element-wise and when the elements or required number of elements are in an adequate range the same, the decision not to continue the repetition is made. The adequate range is dependent on calculation accuracy and/or channel measurement accuracy. Also in this option, time used for the iteration may be limited. It should be appreciated that the updating may be carried out in frequency selective manner with a predetermined granularity in the frequency domain. Since it is quite likely that at least some of the interfering sources are the same, the interference scenario of the previous frame is most probably similar to the current interference scenario. Hence using the pre-coding matrix last used, and/or other last estimated equivalent channel information, as a starting point for adaptation of the first pre-coding matrix or as input used to calculate the first pre-coding matrix, may result to a smaller trade-off compared to solutions using a randomly chosen first pre-coding matrix or a predefined initial pre-coding matrix as a starting point.

In one embodiment, the repetition loop or iteration is triggered in a periodical manner or on a need basis. In yet another embodiment, sequential transmissions of pre-coded reference signals are carried out during one sub-frame or frame.

The pre-coding matrices may be conveyed (transmitted/received) by using a respective reference signal.

After the pre-coding matrix is updated, a data transmission using the updated first pre-coding matrix may be caused (block 508).

Additionally, frequency domain multiplexing with a predetermined allocation granularity may be taken into account when the first pre-coding matrix is updated based on the received second pre-coded reference signal(s). In other words, there is a common first reference signal covering all user devices in the service area of the access node, and the first pre-coding matrix may be updated in such a way that different user devices occupy different frequency portions of the reference signal. Furthermore, the updating may be performed using a given minimum frequency domain allocation granularity, such as N physical resource blocks. This parameter N may be predefined by the system design or it may be configured by higher layer signaling. The purpose of taking into account the frequency domain multiplexing with a predetermined allocation granularity is to try to ensure that interference scenario does not change during the defined minimum allocation granularity. Hence, the access node may improve the estimation accuracy by frequency domain averaging over the N physical resource blocks.

In one embodiment, a user device may be informed on the second resource type and/or on the link direction. For example, user devices may be instructed for each transmitted sub-frame, such as a TTI sub-frame, or a radio frame to transmit their pre-coded pilots either in the forward phase or the backward phase depending on whether the cell is in the UL or DL mode. The link direction may be derived implicitly from UL/DL scheduling assignments. Additionally or alternatively, an explicit indicator similarly to

3GPP Rel-12 enhanced interference mitigation and traffic adaptation (eIMTA) may be provided indicating the link direction for a frame (this indicator is called as "UL-DL reconfiguration indication" in eIMTA).

Another embodiment starts in block 600 of Figure 6. This embodiment may be carried out by a user device or the enhanced pre-coder unit.

In block 602, a first pre-coded reference signal is received from an access node. The first pre-coded reference signal uses a first resource type and is pre-coded by using a first pre-coding matrix.

As described above, the first reference signal may be a pilot signal, a sounding reference signal (SRS), channel state information reference signal (CSI-RS), or any other signal suitable for channel estimation. Such a signal is a kind of a training sequence, in other words a known signal transmitted for channel matrix estimation purposes. For example, long term evolution (LTE) time division duplex (TDD) systems, node Bs use up-link sounding reference signals (SRSs) to estimate downlink channel state information (CSI) for downlink beamforming transmissions.

In block 604, a second pre-coding matrix is determined.

The second pre-coding matrix may be determined based on the received first pre-coded signal or based on a predetermined pre-coding matrix and/or measurements the user device carries out on a reference signal received from (transmitted by) an access node (the first pre-coded reference signal). It may also be a pre-coding matrix last used (such as for a previous data transmission or used in a previous frame), a pre-coding matrix chosen randomly or a predefined initial pre-coding matrix. It should be appreciated that "matrix" also comprises $1 \times m$ or $m \times 1$ matrix or a row or column vector (m is an integer ≥ 1). Examples of determining of pre-coding matrices are discussed in further detail above.

In block 606, a link direction and a second resource type are determined, the second resource type being in proportion to the link direction.

The link direction is either uplink or downlink. As presented above, uplink and downlink resources, such as time-division-duplex (TDD) frames, may be dynamically (not statically) allocated either to UL or DL usage depending on the instantaneous traffic load of the cell.

Resource types may be a forward phase and a backward or reverse phase as expressed by terms used in routing traffic or in radio communication meaning the direction of the traffic (forward towards a user device, backward or reverse towards an access node (or vice versa), for example).

The second resource type may be derived from the first pre-coded reference signal or it can be received in a separate message from the access node. For example, if the link direction is uplink, the second resource type is a forward phase, and if the link direction is downlink, the second resource type is a backward phase.

In block 608, the second reference signal is pre-coded by using the second pre-coding matrix and transmitted to the access node using the second resource type.

Pre-coding may be carried out by multiplying the signal before transmission by a pre-coding matrix. Pre-coding is discussed above.

The second reference signal may be a pilot signal, channel state information reference signal (CSI-RS), sounding reference signal (SRS) or any other signal suitable for channel estimation.

An example of resource usage is shown in above described Figure 4: For example, if the link direction is uplink, the first resource type is a backward phase and the second resource type is a forward phase, and if the link direction is downlink, the first resource type is a forward phase and the second resource type is a backward phase.

In block 610, if the second pre-coding matrix is not determined based on the received first pre-coded signal, the second pre-coding matrix is updated based on the received first pre-coded signal.

The embodiment ends in block 612.

An embodiment for updating or adapting a pre-coding matrix is now explained with reference to Figure 7. This procedure may be executed as a continuation of the embodiment described by means of Figure 6. In principle, the procedure is based on iteration: transmitting (block 700) the second pre-coding matrix or the updated second pre-coding matrix to the access node using the second resource type, receiving (block 702) an updated first pre-coding matrix using the first resource type from the access node, updating (block 704) the second pre-coding matrix based on the received updated first pre-coding matrix, and repeating the transmitting, receiving and updating until a predefined condition (block 706) is met. Several options for the predefined condition exist, for example the predefined condition may be a fixed number of repetition rounds, the number of repetition rounds is typically determined as a trade-off between time needed and wanted compensation accuracy. Another option is based on comparing the updated first pre-coding matrix and the updated second pre-coding matrix and determining based on the comparison, whether to update the first updated pre-coding matrix. In this option, matrices may be compared element-wise and when the elements or required number of elements are in an adequate range the same, the decision not to continue the repetition is made. The adequate range is dependent on calculation accuracy and/or channel measurement accuracy. Also in this option, time used for the iteration may be limited. A still further option for the predefined condition is to continue the iteration until an indication to stop the iteration, or corresponding information, like indication that the pre-coding matrixes are synchronized, is received from the access node.

It should be appreciated that the updating may be carried out in frequency selective manner with a predetermined granularity in the frequency domain.

In one embodiment, the repetition loop or iteration is triggered in a periodical manner or on a need basis. In yet another embodiment, sequential transmissions of pre-coded reference signals are carried out during one sub-frame or frame.

The pre-coding matrices may be conveyed (transmitted/received) by using a

respective reference signal.

After the pre-coding matrix is updated, a data transmission using the updated second pre-coding matrix may be caused (block 708).

In an embodiment, the user device is further configured to limit or adjust the bandwidth used for transmitting the second pre-coded reference signal. For example, the bandwidth may be adjusted to be the same as the bandwidth to be used for reference signal in the data transmission.

Additionally, the updating of the second pre-coding matrix may be performed using a given minimum frequency domain allocation granularity, such as N physical resource blocks. This parameter N may be predefined by the system design or it may be configured by higher layer signaling. The purpose of taking into account the frequency domain multiplexing with a predetermined allocation granularity is to try to ensure that interference scenario does not change during the defined minimum allocation granularity. Hence, the user device may improve the estimation accuracy by frequency domain averaging over the N physical resource blocks.

The blocks, signaling messages and related functions described above in Figures 3, 5, 6 and 7 are in no absolute chronological order, and some of the blocks may be performed simultaneously or in an order differing from the given one. For example, a user device may determine the second pre-coding matrix, transmit it and only after that receive the first pre-coding matrix, and correspondingly, the access node may receive the second pre-coding matrix, and only after that determine the first pre-coding matrix. In other words, referring to Figure 6, the process may be performed in the following block order: block 600, block 604, block 606, block 608 and block 602. Correspondingly, referring to Figure 3, the process may be performed in the following block order: block 300, block 308, block 302 (at least partly), block 304, block 306. Other functions may also be executed before or after or between the blocks or within the blocks and other signaling messages sent between the illustrated messages. For example, information on the fixed number of repetition grounds, or the adequate range, and/or the link direction and/or a resource type to be used may be transmitted or received when the process starts, and/or after a corresponding information is determined or selected. Another example includes remaining within the adequate range may be monitored as a background process, for example in fast fading environments. (When a channel coherence time is short compared to the frame length, a pre-coder might gradually become outdated towards the end of the actual data transfer phase). A further example includes transmitting or receiving configuration containing information on resources made available for one or more of the resource types, for example. Some of the blocks or part of the blocks can also be left out or replaced by a corresponding block or part of the block. For example, determining resource types in block 302 in Figure 3 may be omitted, and the first resource type may be resolved, i.e. determined or selected, in block 304 based on the determined link type, or based on the resource type used by the user device. Another example is that determining the second resource type in

block 606 in Figure 6 may be a selection amongst two resource types configured to be usable for conveying pre-coding matrices during the updating/adaptation procedure, the selection being to use the resource type which was not used by the access node.

Although in the above embodiments the pre-coder adaptation or updating procedure is performed between an access node and a user device, it should be appreciated that in real-life networks a corresponding process may be carried out between network nodes and/or user devices, one apparatus providing access to one or more other apparatuses.

By using the bi-directional signaling and/or iterations as described above, it may be possible to reduce the amount of coordination, and hence information exchange, between access nodes.

The techniques described herein may be implemented by various means so that an apparatus/network node/user device implementing one or more functions/operations of a corresponding apparatus/network node/user device described above with an embodiment/example, for example by means of Figure 3, 5, 6 and/or 7, comprises not only prior art means, but also means for implementing the one or more functions/operations of a corresponding functionality described with an embodiment, for example by means of Figure 3, 5, 6 and/or 7, and it may comprise separate means for each separate function/operation, or means may be configured to perform two or more functions/operations. For example, one or more of the means and/or the enhanced pre-coder unit and/or the pre-coder adaptation unit and/or algorithms for one or more functions/operations described above may be software and/or software-hardware and/or hardware and/or firmware components (recorded indelibly on a medium such as read-only-memory or embodied in hard-wired computer circuitry) or combinations thereof. Software codes may be stored in any suitable, processor/computer-readable data storage medium(s) or memory unit(s) or article(s) of manufacture and executed by one or more processors/computers, hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. For a firmware or software, implementation can be through modules (e.g., procedures, functions, and so on) that perform the functions described herein. More detailed descriptions are provided by means of Figures 8 and 9.

Figure 8 is a simplified block diagram illustrating some units for an apparatus 800 configured to be a wireless access apparatus (access node), comprising at least the pre-coder adaptation unit, or configured otherwise to perform functionality described above, for example by means of Figure 3 and/or Figure 5, or some of the functionalities if functionalities are distributed in the future. In the illustrated example, the apparatus comprises an interface (IF) entity 801 for receiving and transmitting information, an entity 802 capable to perform calculations and configured to implement at least the pre-coder adaptation unit described herein, or at least part of functionalities/operations described above, for example by means of Figure 3 and/or Figure 5, as a corresponding unit or a sub-unit if

distributed scenario is implemented, with corresponding algorithms 803, and memory 804 usable for storing a computer program code required for the pre-coder adaptation unit, or a corresponding unit or sub-unit, or for one or more functionalities/operations described above, for example by means of Figure 3 and/or Figure 5, i.e. the algorithms for implementing the functionality/operations described above by means of Figure 3 and/or Figure 5. The memory 804 is also usable for storing other possible information, like one or more initial pre-coders, last received/transmitted pre-coder, or the number of iteration rounds, etc. The interface entity 801 may be a radio interface entity, for example a remote radio head, providing the apparatus with capability for radio communications. The entity 802 may be a processor, unit, module, etc. suitable for carrying out embodiments or operations described above, for example by means of Figure 3 and/or Figure 5.

In other words, an apparatus configured to provide the wireless access apparatus (access node), or an apparatus configured to provide one or more corresponding functionalities as described above, for example by means of Figure 3 and/or Figure 5, is a computing device that may be any apparatus or device or equipment or node configured to perform one or more of corresponding apparatus functionalities described with an embodiment/example above, for example by means of Figure 3 and/or Figure 5, and it may be configured to perform functionalities from different embodiments/examples. The pre-coder adaptation unit, as well as corresponding units and sub-unit and other units, and/or entities described above with an apparatus may be separate units, even located in another physical apparatus, the distributed physical apparatuses forming one logical apparatus providing the functionality, or integrated to another unit in the same apparatus.

The apparatus configured to provide the wireless access apparatus (access node), or an apparatus configured to provide one or more corresponding functionalities described above, for example by means of Figure 3 and/or Figure 5, may generally include a processor, controller, control unit, micro-controller, or the like connected to a memory and to various interfaces of the apparatus. Generally the processor is a central processing unit, but the processor may be an additional operation processor. Each or some or one of the units/sub-units and/or algorithms for functions/operations described herein, for example by means of Figure 3 and/or Figure 5, may be configured as a computer or a processor, or a microprocessor, such as a single-chip computer element, or as a chipset, including at least a memory for providing storage area used for arithmetic operation and an operation processor for executing the arithmetic operation. Each or some or one of the units/sub-units and/or algorithms for functions/operations described above, for example by means of Figure 3 and/or Figure 5, may comprise one or more computer processors, application-specific integrated circuits (ASIC), digital signal processors (DSP), digital signal processing devices (DSPD), programmable logic devices (PLD), field-programmable gate arrays (FPGA), and/or other hardware components that have been programmed and/or will be programmed by downloading computer program code (one or more algorithms) in such a way to carry out one or more functions of one or more embod-

iments/examples. An embodiment provides a computer program embodied on any client-readable distribution/data storage medium or memory unit(s) or article(s) of manufacture, comprising program instructions executable by one or more processors/computers, which instructions, when loaded into an apparatus, constitute the pre-coder adaptation unit or an entity providing corresponding functionality. Programs, also called program products, including software routines, program snippets constituting "program libraries", applets and macros, can be stored in any medium and may be downloaded into an apparatus. In other words, each or some or one of the units/sub-units and/or the algorithms for one or more functions/operations described above, for example by means of Figure 3 and/or Figure 5, may be an element that comprises one or more arithmetic logic units, a number of special registers and control circuits.

Further, the apparatus configured to provide the wireless access apparatus (access node), or an apparatus configured to provide one or more corresponding functionalities described above, for example by means of Figure 3 and/or Figure 5, may generally include volatile and/or non-volatile memory, for example EEPROM, ROM, PROM, RAM, DRAM, SRAM, double floating-gate field effect transistor, firmware, programmable logic, etc. and typically store content, data, or the like. The memory or memories may be of any type (different from each other), have any possible storage structure and, if required, being managed by any database management system. In other words, the memory may be any computer-usable non-transitory medium within the processor, or corresponding entity suitable for performing required operations/calculations, or external to the processor or the corresponding entity, in which case it can be communicatively coupled to the processor or the corresponding entity via various means. The memory may also store computer program code such as software applications (for example, for one or more of the units/sub-units/algorithms) or operating systems, information, data, content, or the like for the processor or the corresponding entity to perform steps associated with operation of the apparatus in accordance with examples/embodiments. The memory, or part of it, may be, for example, random access memory, a hard drive, or other fixed data memory or storage device implemented within the processor/apparatus or external to the processor/apparatus in which case it can be communicatively coupled to the processor/network node via various means as is known in the art. An example of an external memory includes a removable memory detachably connected to the apparatus, a distributed database and a cloud server.

The apparatus configured to provide the wireless access apparatus (access node), or an apparatus configured to provide one or more corresponding functionalities described above, for example by means of Figure 3 and/or Figure 5, may generally comprise different interface units, such as one or more receiving units and one or more sending units. The receiving unit and the transmitting unit each provides an interface entity in an apparatus, the interface entity including a transmitter and/or a receiver or any other means for receiving and/or transmitting information, and performing necessary functions

so that the information, etc. can be received and/or sent. The receiving and sending units/entities may be remote to the actual apparatus and/or comprise a set of antennas, the number of which is not limited to any particular number.

Figure 9 is a simplified block diagram illustrating some units for an apparatus 900 configured to be a user device, comprising at least the enhanced pre-coder unit, or configured otherwise to perform functionality described above, for example by means of Figure 6 and/or Figure 7. In the illustrated example, the apparatus comprises an interface (IF) entity 901 for receiving and transmitting information, one or more user interface (U-IF) entities 901' for user interaction, an entity 902 capable to perform calculations and configured to implement at least the enhanced pre-coder unit described herein, or at least part of functionalities/operations described above, for example by means of Figure 6 and/or Figure 7, with corresponding algorithms 903, and memory 904 usable for storing a computer program code required for the enhanced pre-coder unit, or a corresponding unit for one or more functionalities/operations described above, for example by means of Figure 6 and/or Figure 7, i.e. the algorithms for implementing the functionality/operations described above by means of Figure 6 and/or Figure 7. The memory 904 is also usable for storing other possible information, like one or more initial pre-coders, last received/transmitted pre-coder, or the number of iteration rounds, etc. The entity 902 may be a processor, unit, module, etc. suitable for carrying out embodiments or operations described above, for example by means of Figure 6 and/or Figure 7.

In other words, an apparatus configured to provide the user device, or an apparatus configured to provide one or more corresponding functionalities as described above, for example by means of Figure 6 and/or Figure 7, is a computing device that may be any apparatus or device or equipment or node configured to perform one or more of corresponding user device functionalities described with an embodiment/example above, for example by means of Figure 6 and/or Figure 7, and it may be configured to perform functionalities from different embodiments/examples. The enhanced pre-coder unit, as well as corresponding unit or one or more sub-units and other units, and/or entities described above may be separate units/entities, even located in another physical apparatus, the distributed physical apparatuses forming one logical apparatus providing the functionality, or integrated to another unit/entity in the same apparatus.

The apparatus configured to provide the user device, or an apparatus configured to provide one or more corresponding functionalities described above, for example by means of Figure 6 and/or Figure 7, may generally include a processor, controller, control unit, micro-controller, or the like connected to a memory and to various interfaces of the apparatus. Generally the processor is a central processing unit, but the processor may be an additional operation processor. Each or some or one of the units/sub-units and/or algorithms for functions/operations described herein, for example by means of Figure 6 and/or Figure 7, may be configured as a computer or a processor, or a microprocessor, such as a single-chip computer element, or as a chipset, including at least a memory for

providing storage area used for arithmetic operation and an operation processor for executing the arithmetic operation. Each or some or one of the units/sub-units and/or algorithms for functions/operations described above, for example by means of Figure 6 and/or Figure 7, may comprise one or more computer processors, application-specific integrated circuits (ASIC), digital signal processors (DSP), digital signal processing devices (DSPD), programmable logic devices (PLD), field-programmable gate arrays (FPGA), and/or other hardware components that have been programmed and/or will be programmed by downloading computer program code (one or more algorithms) in such a way to carry out one or more functions of one or more embodiments/examples. An embodiment provides a computer program embodied on any client-readable distribution/data storage medium or memory unit(s) or article(s) of manufacture, comprising program instructions executable by one or more processors/computers, which instructions, when loaded into an apparatus, constitute the enhanced pre-coder unit or an entity providing corresponding functionality. Programs, also called program products, including software routines, program snippets constituting "program libraries", applets and macros, can be stored in any medium and may be downloaded into an apparatus. In other words, each or some or one of the units/sub-units and/or the algorithms for one or more functions/operations described above, for example by means of Figure 6 and/or Figure 7, may be an element that comprises one or more arithmetic logic units, a number of special registers and control circuits.

Further, the apparatus configured to provide the user device, or an apparatus configured to provide one or more corresponding functionalities described above, for example by means of Figure 6 and/or Figure 7, may generally include volatile and/or non-volatile memory, for example EEPROM, ROM, PROM, RAM, DRAM, SRAM, double floating-gate field effect transistor, firmware, programmable logic, etc. and typically store content, data, or the like. The memory or memories may be of any type (different from each other), have any possible storage structure and, if required, being managed by any database management system. In other words, the memory may be any computer-usable non-transitory medium within the processor, or corresponding entity suitable for performing required operations/calculations, or external to the processor or the corresponding entity, in which case it can be communicatively coupled to the processor or the corresponding entity via various means. The memory may also store computer program code such as software applications (for example, for one or more of the units/sub-units/algorithms) or operating systems, information, data, content, or the like for the processor or the corresponding entity to perform steps associated with operation of the apparatus in accordance with examples/embodiments. The memory, or part of it, may be, for example, random access memory, a hard drive, or other fixed data memory or storage device implemented within the processor/apparatus or external to the processor/apparatus in which case it can be communicatively coupled to the processor/network node via various means as is known in the art. An example of an external memory includes a removable memory detachably connected to the apparatus, a distributed database and a cloud server.

The apparatus configured to provide the user device, or an apparatus configured to provide one or more corresponding functionalities described above, for example by means of Figure 6 and/or Figure 7, may generally comprise different interface entities/units, such as one or more user interfaces and one or more receiving units and one or more sending units. The receiving unit and the transmitting unit each provides an interface entity in an apparatus, the interface entity including a transmitter and/or a receiver or any other means for receiving and/or transmitting information, and performing necessary functions so that the information, etc. can be received and/or sent. The user interfaces and the receiving and sending units may be remote to the actual apparatus. Further, the receiving and sending units may comprise a set of antennas, the number of which is not limited to any particular number.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. An apparatus comprising:
 - at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:
 - determine a first pre-coding matrix, a plurality of resource types and a link direction;
 - select a first resource type for a first reference signal from the plurality of resource types based on the link direction;
 - pre-code the first reference signal by using the first pre-coding matrix and transmit to a user device the pre-coded first reference signal using the first resource type;
 - receive a second pre-coded reference signal from the user device, the second pre-coded reference signal using a second resource type from the plurality of resource types and being pre-coded by using a second pre-coding matrix; and
 - update the first pre-coding matrix based on the received second pre-coded reference signal.
2. The apparatus of claim 1, further comprising causing the apparatus to:
 - transmit the updated first pre-coding matrix using the first resource type to the user device;
 - receive an updated second pre-coding matrix using the second resource type from the user device; and
 - repeat the updating, transmitting and receiving until a predefined condition is met.
3. The apparatus of claim 2, wherein the predefined condition is a fixed number of repetition rounds.
4. The apparatus of claim 2, wherein the predefined condition is based on comparing the updated first pre-coding matrix and the updated second pre-coding matrix and determining based on the comparison, whether to update the first updated pre-coding matrix.
5. The apparatus of any preceding claim, wherein, if the link direction is uplink, the first resource type is a backward phase and the second resource type is a forward phase, and if the link direction is downlink, the first resource type is a forward phase and the second resource type is a backward phase.

6. The apparatus of any preceding claim, further comprising causing the apparatus to:

cause a data transmission using the updated first pre-coding matrix.

7. The apparatus of any preceding claim, further comprising causing the apparatus to:

adjust a bandwidth for the transmitting of the pre-coded first reference signal.

8. The apparatus of any preceding claim, further comprising causing the apparatus to:

inform the user device on the second resource type and/or on the link direction.

9. An apparatus comprising:

at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

receive a first pre-coded reference signal from an access node, the first pre-coded reference signal using a first resource type and being pre-coded by using a first pre-coding matrix;

determine a second pre-coding matrix based on the received first pre-coded signal or based on a predetermined pre-coding matrix;

determine a link direction and a second resource type, the second resource type being in proportion to the link direction;

pre-code the second reference signal by using the second pre-coding matrix and transmit to the access node the pre-coded second reference signal using the second resource type; and

if the second pre-coding matrix is determined based on the predetermined pre-coding matrix, update the second pre-coding matrix based on the received first pre-coded signal.

10. The apparatus of claim 9, the link direction and the second resource type being determined based on either the received first pre-coded reference signal or information message received from the access node.

11. The apparatus of claim 9 or 10, further comprising causing the apparatus to:

transmit the second pre-coding matrix or the updated second pre-coding matrix to the access node using the second resource type;

receive an updated first pre-coding matrix using the first resource type from the access node;

update the second pre-coding matrix based on the received updated first pre-coding matrix; and

repeat the transmitting, receiving and updating until a predefined condition is met.

12. The apparatus of claim 11, wherein the predefined condition is a fixed number of repetition rounds.

13. The apparatus of claim 11, wherein the predefined condition is based on comparing the updated first pre-coding matrix and the updated second pre-coding matrix and determining based on the comparison, whether to update the second updated pre-coding matrix.

14. The apparatus of any preceding claim 9 to 13, wherein, if the link direction is uplink, the first resource type is a backward phase and the second resource type is a forward phase, and if the link direction is downlink, the first resource type is a forward phase and the second resource type is a backward phase.

15. The apparatus of any preceding claim 9 to 14, further comprising causing the apparatus to:

cause a data transmission using the updated second pre-coding matrix.

16. The apparatus of any preceding claim 9 to 15, further comprising causing the apparatus to:

adjust a bandwidth for the transmitting of the pre-coded second reference signal.

17. A method comprising:

determining, by a first apparatus, at least a first pre-coding matrix and a link direction;

resolving a first resource type for a first reference signal based on the link direction;

pre-coding the first reference signal by using the first pre-coding matrix and causing transmission of the pre-coded first reference signal from the first apparatus to a second apparatus using the first resource type;

receiving a second pre-coded reference signal from the second apparatus, the second pre-coded reference signal using a second resource type from the plurality of resource types and being pre-coded by using a second pre-coding matrix; and

updating the first pre-coding matrix based on the received second pre-coded reference signal.

18. The method of claim 17, wherein
the determining further comprises determining a plurality of resource types;
and
the resolving comprises selecting the first resource type from the plurality of resource types based on the link direction.

19. The method of claim 17 or 18, further comprising:
causing transmission of the updated first pre-coding matrix from the first apparatus to the second apparatus using the first resource type;
receiving an updated second pre-coding matrix using the second resource type from the second apparatus; and
repeating the updating, causing transmission and receiving until a predefined condition is met.

20. The method of claim 17, 18 or 19, wherein the predefined condition is based on comparing the updated first pre-coding matrix and the updated second pre-coding matrix and determining based on the comparison, whether to update the first updated pre-coding matrix.

21. The method of claim 17, 18, 19 or 20, further comprising:
causing a data transmission using the updated first pre-coding matrix.

22. The method of any preceding claim 17 to 21, further comprising:
adjusting a bandwidth for the transmitting of the pre-coded first reference signal.

23. The method of any preceding claim 17 to 22, further comprising:
informing the second apparatus on the second resource type and/or on the link direction.

24. A method comprising:
receiving in a second apparatus a first pre-coded reference signal from a first apparatus, the first pre-coded reference signal using a first resource type and being pre-coded by using a first pre-coding matrix;
determining a second pre-coding matrix based on the received first pre-coded signal or based on a predetermined pre-coding matrix;

determining a link direction and a second resource type, the second resource type being in proportion to the link direction;

pre-coding the second reference signal by using the second pre-coding matrix and causing transmission of the pre-coded second reference signal from the second apparatus to the first apparatus using the second resource type.

25. The method of claim 24, wherein, if the second pre-coding matrix is determined based on the predetermined pre-coding matrix, the method further comprises updating the second pre-coding matrix based on the received first pre-coded signal.

26. The method of claim 25, further comprising:
causing transmission of the updated second pre-coding matrix.

27. The method of claim 24, 25 or 26, further comprising determining the link direction and the second resource type based on either the received first pre-coded reference signal or information message received from the first apparatus.

28. The method of any preceding claim 24 to 27, further comprising:
causing transmission of the second pre-coding matrix or the updated second pre-coding matrix to the first apparatus using the second resource type;
receiving an updated first pre-coding matrix using the first resource type from the first apparatus;
updating the second pre-coding matrix based on the received updated first pre-coding matrix, and
repeating the causing the transmission, receiving and updating until a predefined condition is met.

29. The method of any preceding claim 24 to 28, further comprising:
causing a data transmission using the updated second pre-coding matrix.

30. The method of any preceding claim 24 to 29, further comprising:
adjusting a bandwidth for the transmitting of the pre-coded second reference signal.

31. The method of any preceding claim 24 to 30, wherein the predefined condition is based on comparing the updated first pre-coding matrix and the updated second pre-coding matrix and determining based on the comparison, whether to update the second updated pre-coding matrix.

32. The method of any preceding claim 17 to 31, wherein the predefined condition is a fixed number of repetition rounds.

33. The method of any preceding claim 17 to 32, wherein, if the link direction is uplink, the first resource type is a backward phase and the second resource type is a forward phase, and if the link direction is downlink, the first resource type is a forward phase and the second resource type is a backward phase.

34. An apparatus comprising means for carrying out the method according to any one of claims 17 to 33.

35. The apparatus of any preceding claim 1 to 16 and 34, further comprising a radio interface entity providing the apparatus with capability for radio communications.

36. A non-transitory computer readable media having stored there-on instructions that, when executed by an apparatus, cause the apparatus to:

- determine a first pre-coding matrix, a plurality of resource types and a link direction;

- select a first resource type for a first reference signal from the plurality of resource types based on the link direction;

- pre-code the first reference signal by using the first pre-coding matrix and transmit to a user device the pre-coded first reference signal using the first resource type;

- receive a second pre-coded reference signal from the user device, the second pre-coded reference signal using a second resource type from the plurality of resource types and being pre-coded by using a second pre-coding matrix; and

- update the first pre-coding matrix based on the received second pre-coded reference signal.

37. A non-transitory computer readable media having stored there-on instructions that, when executed by an apparatus, cause the apparatus to: receive a first pre-coded reference signal from an access node, the first pre-coded reference signal using a first resource type and being pre-coded by using a first pre-coding matrix;

- determine a second pre-coding matrix based on the received first pre-coded signal or based on a predetermined pre-coding matrix;

- determine a link direction and a second resource type, the second resource type being in proportion to the link direction;

- pre-code the second reference signal by using the second pre-coding matrix and transmit to the access node the pre-coded second reference signal using the second resource type; and

if the second pre-coding matrix is determined based on the predetermined pre-coding matrix, update the second pre-coding matrix based on the received first pre-coded signal.

38. A computer program product comprising program instructions configuring an apparatus to perform any of the steps of a method as claimed in any preceding claims 17 to 33 when the computer program is run.

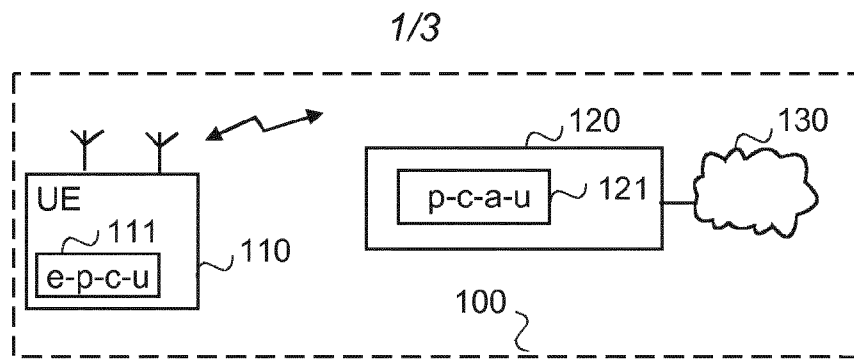


FIG.1

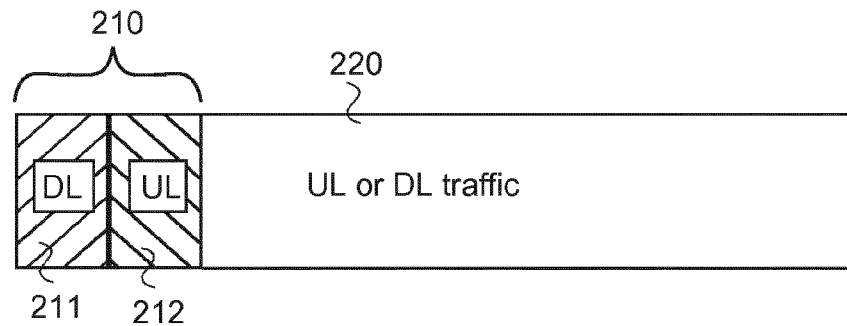


FIG.2

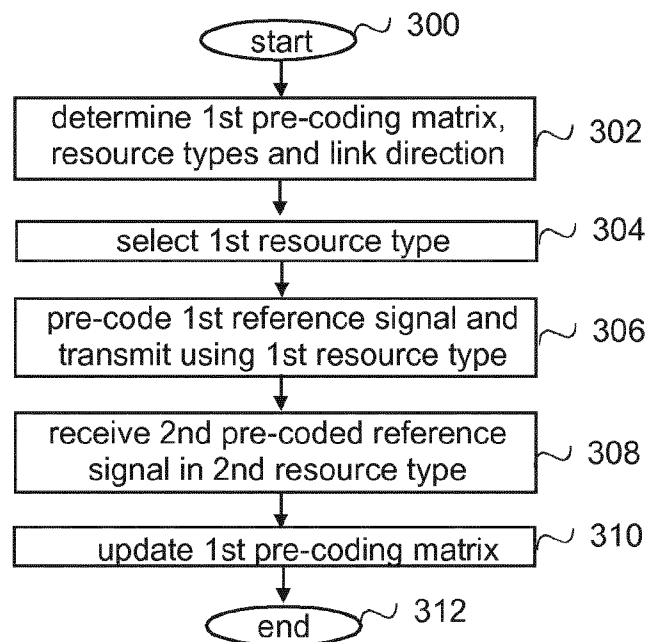


FIG.3

2/3

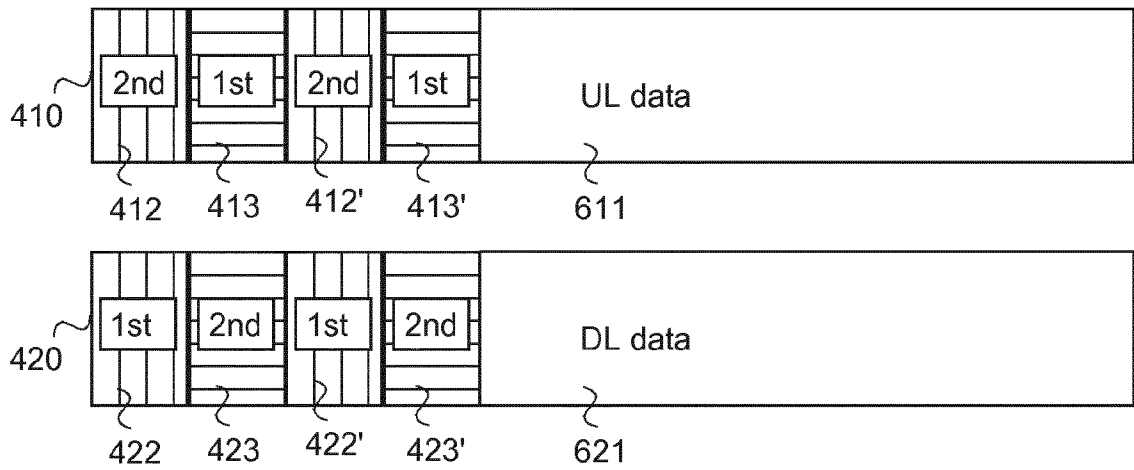


FIG.4

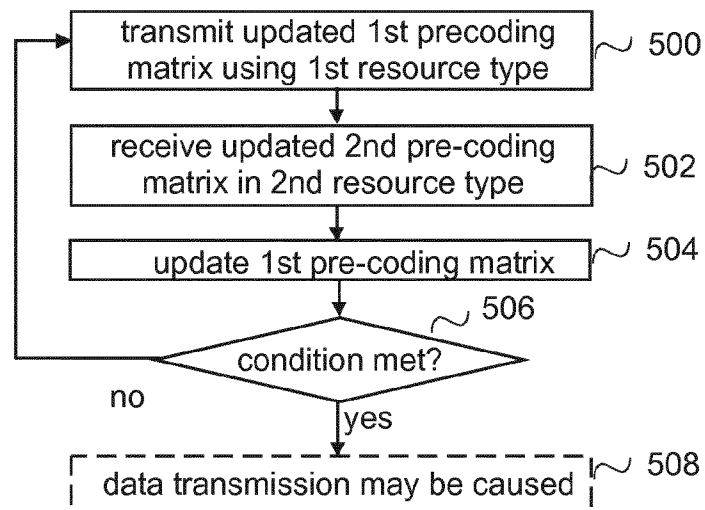


FIG.5

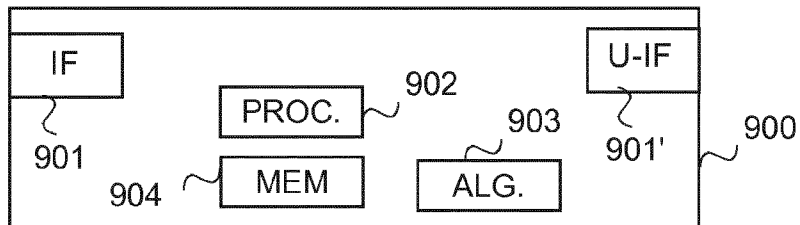


FIG.9

3/3

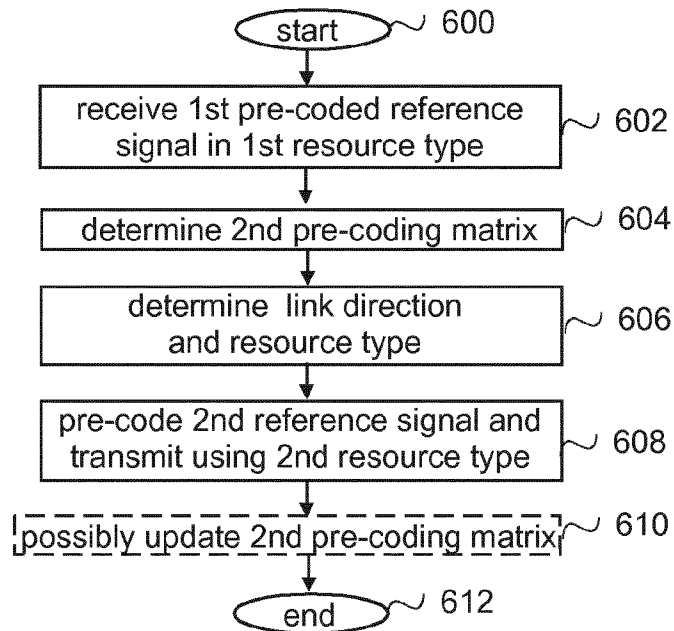


FIG. 6

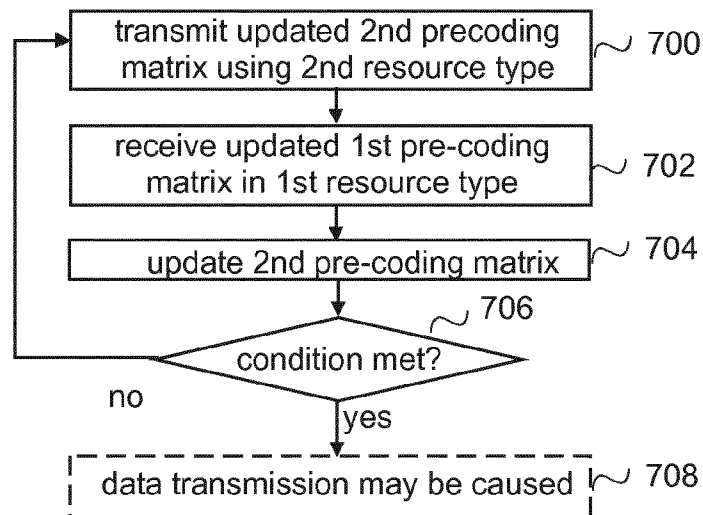


FIG. 7

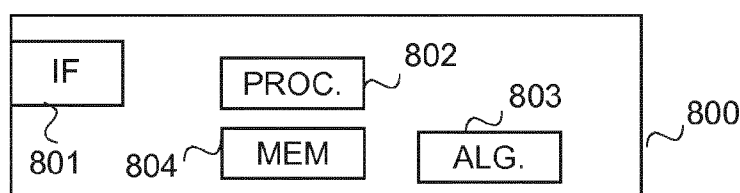


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/053489

A. CLASSIFICATION OF SUBJECT MATTER		
INV. H04L25/03	H04L5/14	H04B7/06 H04B7/08 H04B7/04
ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) H04L H04B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DAC-UPC ET AL: "Coordinated Sounding for CoMP BF (CoMP BF-CoS) including calibration information", 3GPP DRAFT; R1-135239 (COMP COS BF), 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. San Francisco, US; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050734937, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13] 1. Introduction 2.a Basic Principles -/--	1-38
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
8 October 2015		23/10/2015
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Palacián Lisa, Marta

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/053489

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	2.b Algorithm description 3. UE behaviour -----	
X	MITSUBISHI ELECTRIC: "Exploiting channel reciprocity in TDD/MIMO with asymmetric interference", 3GPP DRAFT; R1-091144, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. Seoul, Korea; 20090318, 18 March 2009 (2009-03-18), XP050338768, [retrieved on 2009-03-18] 1. Introduction 2.1 Principle of Proposed CSI Reporting 2.2 Procedure of Proposed CSI Reporting 3. Scenarios of Applying Proposed Method in LTE-Advanced -----	1-38
X	US 2009/046800 A1 (XU HAO [US] ET AL) 19 February 2009 (2009-02-19) abstract paragraph [0010] paragraph [0022] - paragraph [0048] paragraph [0063] - paragraph [0073] paragraph [0080] - paragraph [0082] -----	1,9,17, 24,34-38
X	US 2014/066113 A1 (ZHUANG BINNAN [US] ET AL) 6 March 2014 (2014-03-06) abstract paragraph [0002] paragraph [0006] paragraph [0026] paragraph [0037] - paragraph [0050] -----	1,9,17, 24,34-38
A	EP 2 034 682 A2 (BROADCOM CORP [US]) 11 March 2009 (2009-03-11) abstract paragraph [0007] - paragraph [0008] paragraph [0041] - paragraph [0049] paragraph [0052] - paragraph [0053] paragraph [0076] - paragraph [0082] -----	1-38
A	US 2008/187062 A1 (PAN KYLE JUNG-LIN [US] ET AL) 7 August 2008 (2008-08-07) abstract paragraph [0011] - paragraph [0016] paragraph [0024] - paragraph [0026] paragraph [0034] -----	1-38

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/053489

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009046800	A1	19-02-2009	AU 2008286923 A1 19-02-2009 BR PI0814945 A2 27-01-2015 CA 2694168 A1 19-02-2009 CN 101843062 A 22-09-2010 EP 2183892 A2 12-05-2010 JP 5431325 B2 05-03-2014 JP 2011517373 A 02-06-2011 JP 2014014101 A 23-01-2014 KR 20100044258 A 29-04-2010 RU 2010109400 A 20-09-2011 TW 200924451 A 01-06-2009 US 2009046800 A1 19-02-2009 WO 2009023681 A2 19-02-2009
US 2014066113	A1	06-03-2014	NONE
EP 2034682	A2	11-03-2009	CN 101459461 A 17-06-2009 EP 2034682 A2 11-03-2009 HK 1138119 A1 16-05-2013 KR 20090026101 A 11-03-2009 TW 200931900 A 16-07-2009 US 2009066577 A1 12-03-2009 US 2012106603 A1 03-05-2012
US 2008187062	A1	07-08-2008	US 2008187062 A1 07-08-2008 WO 2008097629 A2 14-08-2008