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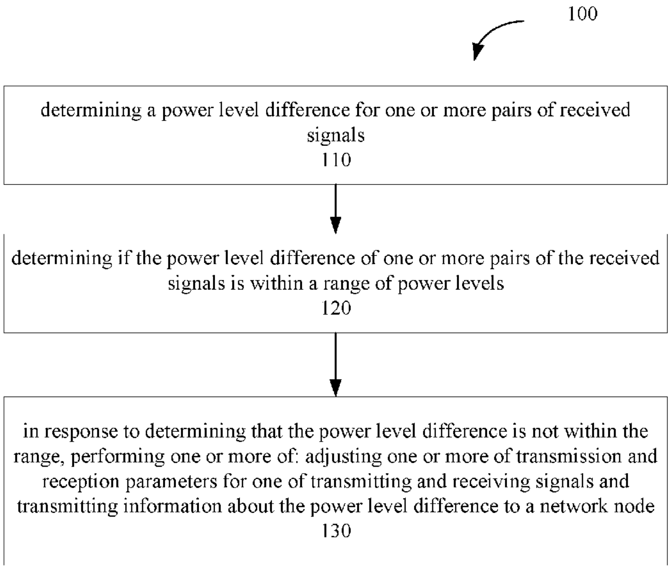

Figure 6

(57) **Abstract:** There is provided a method in an Integrated Access Backhaul (IAB) network for simultaneous reception of different signals from different cells or the same cell at an IAB node. The method may comprise: determining a power level difference for one or more pairs of received signals; determining if the power level difference of one or more pairs of the received signals is within a range of power levels; and in response to determining that the power level difference is not within the range, performing one or more of: adjusting one or more of transmission and reception parameters for one of transmitting and receiving signals and transmitting information about the power level difference to a network node. A network node is also provided to implement this method.

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METHODS AND NODES FOR SIMULTANEOUS RECEPTION ON BACKHAUL AND ACCESS LINKS IN IAB NODES

RELATED APPLICATIONS

[0001] This application claims the benefits of priority of U.S. Provisional Patent Application No. 62/975,885, entitled “Simultaneous reception on backhaul and access in IAB nodes” and filed at the United States Patent and Trademark Office on February 13, 2020, the content of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present description generally relates to wireless communication systems and more specifically to handle simultaneous reception on backhaul and access links in Integrated Access and Backhaul (IAB) Nodes.

BACKGROUND

[0003] In Third Generation Partnership Project (3GPP), there is an ongoing Work Item (WI) for Integrated Access Backhaul (IAB) based on earlier study item documented in 3GPP TR 38.874. The purpose of IAB is to replace existing wired backhaul or wireless backhaul with flexible wireless backhaul using the existing 3GPP bands providing not only backhaul (BH) but also existing cellular services in the same node. With IAB, in addition to create more flexibility, the purpose is generally to reduce the cost for a wired backhaul, which in certain deployments could impose a large cost for the installation and operation of the Base Station (BS).

[0004] Each IAB node in the chain of nodes acts as a child node towards the upstream IAB node and a parent node towards the downstream IAB node, as depicted in Figure 1. For instance, Figure 1 illustrates the different IAB link types. The IAB node can receive downlink (DL) parent BH traffic from a parent node, Uplink (UL) access traffic from a User Equipment (UE) and UL child BH traffic from a child node.

[0005] A donor node (e.g. donor IAB node) is an IAB node closest to a core network and is the only node connected to a wired backhaul, as depicted in Figure 2A.

[0006] Each IAB node holds a Distributed Unit (DU) function and a Mobile-Termination (MT) function as shown in the reference architecture in Figure 2B (see fig. 6.3.1-1 in 3GPP TR38.874, for example).

[0007] Via the MT, the IAB-node connects to an upstream IAB-node or the IAB-donor. Via the DU, the IAB-node establishes Radio Link Control (RLC) channels with UEs and MTs of downstream IAB-nodes. Figure 2B shows an IAB chain with two hops, where the IAB donor node is connected to the Core Network (CN) via fiber. The IAB-MT is responsible for the backhaul communication to the parent IAB DU, denoted as parent IAB backhaul DL and backhaul UL (see Figure 1). The IAB-DU is responsible for both UE access (access UL and access DL, see Figure 1), as well as the backhaul to the child IAB MT, including child IAB backhaul DL and backhaul UL.

[0008] In order to reduce the latency of backhaul traffic, it will be preferable that the IAB-MT and IAB-DU at one IAB node could be receiving at the same time or transmit at the same time. In the case of simultaneous reception, an IAB node may at the same time be receiving from access UL, parent IAB backhaul DL and child IAB backhaul UL, or any of the following combinations:

[0009] Case 1: IAB DU simultaneously receiving from the access UL (UE uplink) and UL Child BH.

[0010] Case 2: IAB MT and IAB DU simultaneously receiving from DL Parent BH and UL Access at the same receiver (UE uplink).

[0011] Case 3: IAB MT and IAB DU simultaneously receiving from both the parent IAB backhaul DL and child IAB backhaul UL.

[0012] In the general case, transmit (TX) power of the DL Parent BH transmission is controlled by the parent IAB node, while TX power of the UL Child BH transmission and UL Access transmission is controlled by the IAB node. In some Time Division Multiplexing (TDM) cases, where the IAB-DU and IAB-MT are configured with time-wise orthogonal transmission slots, the IAB-MT may transmit during periods of time and frequencies normally allocated for UE to BS transmissions, i.e. access UL. When such transmissions are made, the IAB node will operate the transmit power control on the IAB-MT TX power, similarly to a UE problem with existing solutions.

[0013] For Case 1, the IAB-MT transmitter of a child IAB backhaul UL transmitter may have lower TX dynamic range than UEs transmitting on access UL. This results in that the power spectrum density (PSD) of the signal received from a child IAB-MT and a Release (Rel)-15 UE may not be the same, assuming both IAB-MT and Rel-15 UE use the same transmission bandwidth. The reason that the PSD differs is that, although a power control is applied, the child IAB backhaul link has a lower TX dynamic range and hence cannot follow the power control and reduce its transmit power sufficiently to equalize the PSD between the two links.

[0014] In Case 2 and Case 3, there is a similar problem of large PSD difference between (parent) DU backhaul DL and/or UE access UL and/or (child) MT backhaul UL signal.

[0015] At a receiver, when the PSD difference between the received signals is too large, the noise resulting from a high-power signal may interfere with the low PSD signal and degrade the detection and decoding performance of the low PSD signal. The degradation arises due to diverse hardware limitations, such as a limited Analog to Digital Converter (ADC) dynamic range, intermodulation, phase noise level, etc. Recovery of the low PSD signal is compromised, and the achievable data rate is reduced, or, in the worst case, the low PSD reception might fail completely due to a too degraded Signal to Noise Ratio (SNR). As such, solutions to mitigate Cases 1 to 3 are needed.

SUMMARY

[0016] In the scenarios as described above, two signals from different transmitters are received with a PSD difference (ΔP) at the same receiver. The difference in the PSD may result from a power difference of the transmitters. The PSD difference could be reduced or eliminated by adjusting the transmit power of one or more transmitters. However, due to the preferred installation site and limited TX dynamic range, in many circumstances, it may not be possible to remove or reduce such PSD difference below an acceptable value through power adjustment of one or more transmitters. For example, the maximum TX powers of IAB MT and UE may differ by a large margin. Furthermore, the transmission power, and, the change in the transmission power are associated with inaccuracies or tolerances, e.g. UE relative TX power tolerance can be ± 5dB even if the power change is up to 2 dB. Therefore, there is a need to mitigate the PSD difference problem.

[0017] Embodiments in this disclosure allow to mitigate or solve the PSD difference problem.

[0018] In an example, the receiver’s dynamic range is compared to the receiver’s PSD difference. Evaluation/measurement of the different signals’ received power may for example be performed by configuring the TDM operation of the separate links such that the PSD difference can be derived. Considering the likely modulation settings, the receiver’s PSD difference can be compared to the achievable receive (RX) dynamic range to decide if the receiver can handle the PSD difference (ΔP) or not.

[0019] In another example, if simultaneous reception of different links cannot be operated due to a too high PSD difference (e.g. ΔP > a threshold) and/or exceeding a receiver’s dynamic range, information about such situation is transmitted to a higher node (e.g. IAB parent, donor node) so that e.g. a Space Division Multiplexing (SDM)/ Frequency Division Multiplexing (FDM) operation of the parent- and/or child-node and/or UE is avoided. This solution requires specification of new signaling between the IAB node and its IAB parent and/or donor node.

[0020] In another example, an IAB node experiencing higher ΔP than the threshold may stop performing such operation, i.e. simultaneous reception of signals from two or more transmitting nodes (e.g. child IAB-node's MT and UE). This solution requires the IAB scheduler to avoid scheduling (e.g. in UL) conflicting nodes at the same time. If a received PSD in DL is too high, a solution can require specification of new signaling between the IAB node and its IAB parent or donor node.

[0021] A further solution applicable to only Case 1 could be to increase the signal-to-interference-plus-noise ratio (SINR) or RX power target for the UE power control in order to achieve similar PSD on the Access and Child BH link.

[0022] In another example, the Radio Frequency (RF) parameters on IAB MT or IAB DU can be adjusted as follows:

[0023] - Array antenna excitation (including tapering and disabling elements) of the IAB-MT transmitter may be adjusted to reduce the Equivalent Isotropically Radiated Power (EIRP);

[0024] - Transceiver transmitter power of subarray may be adjusted;

[0025] - Beamforming shape to tune EIRP (e.g. miss-direct by moving the peak away from the victim) may be adjusted;

[0026] - RX beamforming gain may be adjusted away from the transmitter with the higher received PSD if analog beamforming is implemented.

[0027] In another example, after checking that there is no or sufficiently low distortion in the analog receiver for the different signals, the high PSD noise to the low PSD signal could be reduced with additional filter attenuation in the digital domain.

[0028] There may be further actions that may be taken in the baseband or on the physical layer. For example:

[0029] - The receiving IAB node may, e.g., perform successive interference cancellation on the received signals, a procedure known in the art. Thereby, the receiver starts by receiving the stronger signal, and based on the received data, constructs a model of the PSD interference in adjacent spectrum. This interference is then subtracted before the weaker signal is decoded.

[0030] - The IAB node can apply spectrum planning in the scheduler such that weaker signals are further away in frequency from a strong interferer compared to stronger signals. Thereby, some of the problems may be reduced and system performance improved. One special case, provided that sufficient spectrum exists, is to allocate a buffer between the stronger signal and the weaker signal. Typically, interference is worse in close vicinity to the interferer and by moving the weaker signal further away, interference in the weaker signal may be reduced. The spectrum planning may involve signaling to other IAB nodes such that a spectrum allocation is agreed on beforehand to allow the IAB node to schedule other IAB nodes or UEs more optimally with this agreement in mind.

[0031] According to an aspect, some embodiments include methods performed by a network node. For example, a method for simultaneous reception of different signals from different cells or the same cell at an IAB node may comprise: determining a power level difference for one or more pairs of received signals; determining if the power level difference of one or more pairs of the received signals is within a range of power levels; and in response to determining that the power level difference is not within the range, performing one of: adjusting one or more of transmission and reception parameters for one of transmitting and receiving signals and transmitting information about the power level difference to a network node.

[0032] Another method in a first network node (e.g. IAB donor node or parent IAB node) may comprise: receiving information about a power level difference for one or more pairs of signals, from a second network node; comparing the received power level difference to a threshold; and based on the comparison, sending an adjustment configuration of one or more of transmission and reception parameters of the second network node, to the second network node.

[0033] According to another aspect, some embodiments include a network node configured, or operable, to perform one or more functionalities (e.g. actions, operations, steps, etc.) as described herein.

[0034] In some embodiments, the network node may comprise one or more communication interfaces configured to communicate with one or more other radio nodes and/or with one or more network nodes, and processing circuitry operatively connected to the communication interface, the processing circuitry being configured to perform one or more functionalities as described herein. In some embodiments, the processing circuitry may comprise at least one processor and at least one memory storing instructions which, upon being executed by the processor, configure the at least one processor to perform one or more functionalities as described herein.

[0035] In some embodiments, the network node may comprise one or more functional modules configured to perform one or more functionalities as described herein.

[0036] According to yet another aspect, some embodiments include a non-transitory computer-readable medium storing a computer program product comprising instructions which, upon being executed by processing circuitry (e.g., at least one processor) of the network node, configure the processing circuitry to perform one or more functionalities as described herein.

[0037] The advantages/technical benefits of the embodiments of the present disclosure are:

[0038] - The performance of simultaneous reception of signals from different transmitting nodes may be enhanced;

[0039] - If enhancement is not sufficient, the signaling solution enables the IAB parent or donor node to avoid the problems related to the higher PSD difference experienced by the IAB child node;

[0040] - The signaling solution also enables the IAB parent or donor node to assist the IAB child node to apply one or more mitigation techniques to serve other nodes when higher PSD difference is experienced by the IAB child node.

[0041] By so doing, the flexibility and capacity of an IAB solution is enhanced.

[0042] This summary is not an extensive overview of all contemplated embodiments and is not intended to identify key or critical aspects or features of any or all embodiments or to delineate the scope of any or all embodiments. In that sense, other aspects and features will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] Exemplary embodiments will be described in more detail with reference to the following figures, in which:

[0044] Figure 1 illustrates different IAB link types.

[0045] Figure 2A illustrates a reference diagram for IAB architectures (SA mode).

[0046] Figure 2B illustrates a reference diagram for IAB architecture 1a (SA mode with NGC).

[0047] Figure 3 illustrates an exemplary scenario where an IAB node receives different signals simultaneously.

[0048] Figure 4 illustrates a receive signal power of different arriving directions (in-beam and out-of-beam).

[0049] Figure 5 illustrates an ADC dynamic range and associated PSD difference threshold.

[0050] Figure 6 is a flow chart of a method in a network node, in accordance with an embodiment.

[0051] Figure 7 is a flow chart of a method in a network node, in accordance with an embodiment.

[0052] Figure 8 illustrates one example of a wireless communications system in which embodiments of the present disclosure may be implemented.

[0053] Figures 9 and 10 are block diagrams that illustrate a wireless device according to some embodiments of the present disclosure.

[0054] Figures 11 and 12 are block diagrams that illustrate a network node according to some embodiments of the present disclosure

[0055] Figure 13 illustrates a virtualized environment of a network node, according to some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0056] The embodiments set forth below represent information to enable those skilled in the art to practice the embodiments. Upon reading the following description in light of the accompanying figures, those skilled in the art will understand the concepts of the description and will recognize applications of these concepts not particularly addressed herein. It should be understood that these concepts and applications fall within the scope of the description.

[0057] In the following description, numerous specific details are set forth. However, it is understood that embodiments may be practiced without these specific details. In other instances, well-known circuits, structures, and techniques have not been shown in detail in order not to obscure the understanding of the description. Those of ordinary skill in the art, with the included description, will be able to implement appropriate functionality without undue experimentation.

[0058] References in the specification to “one embodiment,” “an embodiment,” “an example embodiment,” etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to implement such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0059] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “includes,” and/or “including” when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0060] Mitigation mechanism to reduce PSD difference

[0061] In one example, as showed in Figure 3, one IAB node receives three signals simultaneously, namely, the IAB node receives S1 (the downlink signal from IAB parent node (IAB DU)), S2 (the uplink signal from IAB child node (IAB MT)) and S3 (the UE uplink signal from the IAB node access link).

[0062] To save some latency of the backhaul traffic, the 3 above signals could be multiplexed in the receiver simultaneously. However, in a practical deployment scenario, if the received PSD signal level of any two signals is not the same, the low PSD signal quality could be degraded. There are two aspects that degrade the signal demodulation quality:

[0063] - If the high PSD signal is too high and utilize the full ADC dynamic range, the low PSD signal could be distorted/cut off due to the limited receiver dynamic range;

[0064] - When the signals are not distorted by the receiver's dynamic range, the noise of the high PSD signal can interfere with the low PSD signal and thus the low PSD signal's SNR will be degraded.

[0065] To mitigate this problem, the received power of each signal can be adjusted with the following methods:

[0066] M1) Adjust transmitter or receiver antenna array size;

[0067] M2) Adjust the transmitter beam shape;

[0068] M3) Adjust receiver beam shape;

[0069] M4) Decrease the transmitter output power.

[0070] In the following, the different methods will be described in more detail.

[0071] <u>M1) Adjust transmitter or receiver antenna array size</u>

[0072] In this method, the antenna array size of the transmitter or receiver could be adjusted so that the antenna gain could be changed. As the antenna gain of the transmitter or receiver is related to the received power level, the adjustment of the antenna array size will directly change the received power.

[0073] For analog beamforming, as the beam shaping at the receiver side is achieved by adjusting the analog phase and power of different antenna elements, it would only be possible to apply one space filter at one time, preferably for one receiving signal. One space filter means only one beam can be optimized with antenna gain (in-beam) and any other beams will be sub-optimal beam formed (out-of-beam) for simultaneously receiving multiple signals. This also means there will be an additional PSD difference attributed by the space filter. This is illustrated in Figure 4; the highest gain beam is in-beam and all other side lobes are defined as out-of-beam. Table 1 below shows the PSD difference or dynamic range improvement corresponding to different tapering levels.

Table 1: The in-beam direction to out-of-beam dynamic range improvement for several different tapering levels.

Tapering [dB]	In-beam gain update [dB]	Out-of-beam gain update [dB]	Dynamic range gain [dB]
0	0	0	0
-3	-1.8	-4	2
-6	-2.9	-7	4
-20	-4	-13	9

[0074] Here, tapering means changing of the antenna array size. The dynamic range improvement could be used to offset the un-desired PSD difference. As one of the signals would be suboptimal in terms of beam shaping gain, it will be preferable to optimize S3 (from UE) as the UE will be moving, or the signal which is subject to Non-Line of Sight (NLOS).

[0075] M2) Adjust the transmitter beam shape

[0076] The EIRP of a transmitter can be changed by adjusting the beam shape, i.e. from a pencil narrow beam to a wider beam, by applying different antenna phases and power scaling to the antenna elements that transmit S1, S2 or S3. The effect of the change of beam shape will result in an EIRP change. By so doing, the power level on the receiver side will be adjusted.

[0077] M3) Adjust the receiver beam shape

[0078] Similar to the change of the transmitter beam shape, different antenna phases and power scaling factors could be applied to the antenna elements that receive S1, S2 and/or S3 so that the aggregated received signal power can be changed.

[0079] M4) Decrease the transmitter output power

[0080] The power of a transmitter could be reduced by adjusting the power in the digital domain or by changing the bias level of transmitter power amplifiers, i.e. the power amplifier operates at different power levels or analog gains.

[0081] The amount of power reduction and PSD equalization required to be obtained by the above methods depends on several factors, as listed below:

[0082] A1: The SNR threshold to decode a certain Quadrature Amplitude Modulation (QAM);

[0083] A2: The budget for tolerating noise added by the ADC;

[0084] A3: Back-off margin to support higher modulation;

[0085] A4: Margin for receiving different received power level signals;

[0086] A5: Margin to tolerate more hardware related error, e.g. Automatic Gain Control (AGC) error, Gain/Offset error.

[0087] Figure 5 illustrates an ADC dynamic range and a PSD difference threshold where the PSD difference threshold is associated with a part of the ADC dynamic range.

[0088] An example of using a PSD difference and a threshold, in order to decide whether to take the measures listed above (e.g. M1 to M4), may comprise the following steps:

[0089] Step 1: an IAB node measures signal levels of the received signals individually, such as S1, S2 and S3 signals;

[0090] Step 2: the IAB node gets/obtains a level tolerance range in the local IAB for the received signals, i.e. P1 to P2;

[0091] Step 3: the IAB reports to a co-ordination unit what the received level should be controlled and adjusted according to the reported P1 to P2.

[0092] Step 4: the IAB node uses the M1/M2/M3/M4 methods to adjust the received signal level.

[0093] Step 5: the IAB node checks any two of the 3 signals S1, S2 or S3 that could be adjusted within the reported range of P1 to P2.

[0094] Step 6: the IAB node configures the relevant simultaneous receiving operation if the checking of step 5 is ok for any of the two signals.

[0095] Now, turning to Figure 6, a method 100 in an IAB network for preparing or receiving simultaneous reception of different signals from different cells or the same cell at an IAB node will be described. Method 100 may be implemented in network node (or IAB node) 320 of Figure 8. Method 100 comprises:

[0096] Step 110: determining a power level difference for one or more pairs of received signals;

[0097] Step 120: determining if the power level difference of one or more pairs of the received signals is within a range of power levels; and

[0098] Step 130: in response to determining that that the power level difference is not within the range, performing one or more of: adjusting one or more of transmission and reception parameters for one of transmitting and receiving signals and transmitting information about the power level difference to a network node.

[0099] In some examples, the IAB node may measure/determine the power level (gain, energy, etc.) of some or all received signals.

[0100] In some examples, method 100 may comprise, in response to determining that the power level of a pair of received signals difference is within the range, configuring a receiver of the IAB node for simultaneously receiving the pair of signals. For example, the receiver may have shared or separated antenna panels and/or DSPs (digital signal processing units).

[0101] In some examples, method 100 may further comprise obtaining the range of power levels from a local IAB node.

[0102] In some examples, method 100 may further comprise reporting the range of power levels to a co-ordination unit.

[0103] In some examples, adjusting one or more of transmission and reception parameters may comprise adjusting an antenna array size of a transmitter or receiver, adjusting a beam shape of a transmitter or a receiver, or, decreasing an output power of a transmitter.

[0104] In some examples, adjusting the reception parameters may comprise applying different beamforming for two simultaneously received high power level signal and low power signal.

[0105] In some examples, a command of the adjustment of the one or more of transmission and reception parameters is sent to a coordination unit.

[0106] In some examples, the coordination unit is in either a local IAB node or remotely.

[0107] Signaling PSD difference related information to a Node

[0108] In another example, a certain IAB node (e.g. Node0) configured to simultaneously receive signals from two or more transmitting nodes is further configured to transmit information related to the PSD difference (ΔP) between at least two signals to a target node. Examples of transmitting nodes are DU of IAB parent node (e.g. Node1), MT of IAB child node (e.g. Node2) and UE on access link (e.g. Node3) as shown in Figure 3. The corresponding signals S1, S2 and S3 are received by Node0 from Node1, Node2 and Node3 respectively. Examples of the target node are any network nodes, such as the parent IAB parent node, donor IAB node, BS, etc.

[0109] For example, Node0 can be configured to transmit information about the PSD difference for all combinations of pairs of the received signals or for one or more specific combinations of pairs, to the target node. Node0 can be configured by the target node with the information about a set of signals whose PSD difference information is to be transmitted by Node0. For example, Node0 can be configured by the target node to signal information related to one or more ΔP12, ΔP13 and ΔP23, which correspond to ΔP between powers of signals: (S1 and S2), (S1 and S3), and (S2 and S3), respectively. Node0 can also be configured by the target node with the duration over which the PSD difference shall be estimated by Node0.

[0110] It should be clear that knowing the bandwidth that a signal occupies and assuming an average signal power distribution over frequency, the information of a signal power is equivalent to PSD and therefore interchangeable with the information about a signal PSD.

[0111] Node0 can transmit the information about the PSD difference to the target node using different reporting mechanisms, for example:

[0112] - Node0 is configured to transmit the information about the PSD difference to the target node periodically, e.g. once every X second. The periodicity of the transmission can be pre-defined or configured by the target node.

[0113] - Node0 is configured to transmit the information about the PSD difference to the target node only when one or more conditions are met, e.g. event triggered transmission or reporting. For example, the information is transmitted by Node0 based on a relation between ΔP (e.g. any of ΔP12, ΔP13 and ΔP23) and one or more thresholds. For example, if a magnitude of ΔP exceeds a certain threshold (Hp1), then Node0 transmits information to the target node (e.g. called herein as event E1). If a magnitude of ΔP is below a certain threshold (Hp2), then Node0 transmits information to the target node (e.g. called herein as event E2). The thresholds can be pre-defined or configured by the target node. Each reported event may also be associated with certain actions for Node0. For example, upon triggering event E1, Node0 is required or recommended to stop the simultaneous reception of signals from two or more different transmitting nodes (e.g. from Node2 and Node3). Some pre-defined priority rules can be considered for stopping the nodes from transmission. For instance, the stronger node may be stopped from transmission. However, in general, different nodes could be chosen as long as the issue is resolved. In another example, upon triggering event E2, Node0 is allowed or recommended to resume simultaneous reception of signals from two or more different transmitting nodes (e.g. from Node2 and Node3).

[0114] - The information about the PSD difference transmitted to the target node may comprise one or more of the following: the value of the ΔP, information about the type of ΔP (e.g. ΔP12, etc.), information about the signals whose ΔP was estimated for triggering the event or for periodic reporting, the duration over which the ΔP was estimated, etc.

[0115] The target node uses the received information about the PSD difference from Node0 for one or more operational tasks. Examples of tasks may comprise: configuring Node0 not to simultaneously receive signals from two or more nodes (Node1, Node2 and Node3 e.g. if $|\Delta P| > Hp1$), configuring Node0 to resume simultaneous reception of signals from two or more nodes (e.g. if $|\Delta P| < Hp2$), configuring Node0 with a pattern of radio resources (e.g. slots, symbols, etc.) for enabling Node0 to adapt its scheduling, e.g. to enable Node0 to schedule different nodes (e.g. Node2 and Node3) in an orthogonal manner to reduce the PSD difference below an acceptable threshold, to reconfigure the IAB child node (Node2) so that it can be served by another parent IAB node (i.e. different than Node0), etc.

[0116] Based on the just above section (i.e. Signaling PSD difference related information to a Node), method 100 may further comprise the following steps:

[0117] In some examples, when determining the power level difference for one or more pairs of received signals, the IAB node can determine a power spectrum density (PSD) difference between two signals, for the one or more pairs of the received signals.

[0118] In some examples, the IAB node can send information related to the PSD difference of the one or more pairs of the received signals to a target node.

[0119] In some examples, determining the PSD difference may comprise determining the PSD difference for a configured duration.

[0120] In some examples, sending the information related to the PSD difference may comprise sending the information periodically or based on an event. For example,

the event may comprise a comparison of the determined PSD difference with a threshold.

[0121] In some examples, the IAB node may, in response to sending the information, receive a configuration related to receiving subsequent signals.

[0122] In some examples, determining the PSD difference may comprise determining the PSD difference jointly with cross chain interference (CCI) measurements and cross link interference (CLI) measurements.

[0123] In some examples, sending the information related to the PSD difference may comprise sending the information in one of a Radio Resource Control (RRC) message, a F1 AP message, in a Medium Access control (MAC) Control Element (CE) message, and a BAP protocol control message.

[0124] In some example, the information related to the PSD difference may comprise one or more of a value of the PSD difference, information about the type of PSD difference, information about the signals whose PSD difference is estimated for triggering an event or for periodic reporting, a duration over which the PSD difference is estimated, or a range of PSD.

[0125] Furthermore, it should be noted that the PSD control can be an IAB-node local decision, for example:

[0126] - The IAB node can perform M1-M4 to child IAB MT;

[0127] - The IAB node can perform M1-M4 to UE;

[0128] - The IAB node will not schedule simultaneous reception of parent IAB DU, child IAB MT and UE.

[0129] In another example, the PSD control can be coordinated in a centralized manner and the responsible network function can be located at a node in the Radio Access Network (RAN), for example at an IAB-donor-Centralized Unit (CU) or as a separated function residing in the core network (for example the Operation, Administration and Management (OAM function)).

[0130] The coordination unit can be made aware of parameters such as the measured PSD, the IAB node receiver dynamic range, the parent IAB node and or child IAB node transmitter dynamic range, the parent IAB node and child IAB node transmit power dynamic range and the expected receive power range.

[0131] The PSD control may be a sub-function of the centralized interference coordination function. The centralized unit can:

[0132] - adjust a parent node DU hardware configurations (M1-M4) to mitigate/reduce PSD difference;

[0133] - adjust neighboring interfering node DU hardware configurations (M1-M4) to mitigate/reduce PSD difference;

[0134] - advise parent DU about alternative resource multiplexing configurations, for example, the availability of DU soft resource;

[0135] - advise neighboring interfering node about alternative resource multiplexing configurations.

[0136] The IAB node can inform the parent node about multiplexing capability of, for example, parent DU DL, child MT UL and UE UL or parent DU UL, child MT DL and UE DL.

[0137] Based on this information, the parent IAB node can adjust the configuration of resource multiplexing.

[0138] Furthermore, the information about the PSD difference sent to the parent DU or the donor CU can comprise a range of possible values that the transmitter of the high-level PSD could back-off to where each value could correspond to a specific bitrate for the receiver. By giving a range of possible values that the transmitter could reduce its PSD with, the parent DU can select, depending on the traffic situation, how much the transmitter should reduce its PSD in a coordinated way. A reduction of the transmitted PSD will reduce the corresponding link capacity.

[0139] The information about the PSD-difference and any other related information that is needed can be sent to the upstream nodes (parent DU, donor CU) with either RRC messages, F1AP messages, MAC CE messages or using the Bandwidth Allocation Protocol (BAP) control messages.

[0140] Also, the evaluation of the PSD difference can be performed jointly with the cross chain interference (CCI) measurements and cross link interference (CLI) measurements. The measurement configuration can be provided in a centralized manner.

[0141] Mitigation mechanism to reduce high PSD signal interference to low PSD signal

[0142] To reduce interference of a high PSD signal over a low PSD signal, the signals could be further digitally processed with an additional filter so that the high PSD signal noise could be further suppressed. This filter operation could be in the time domain, for OFDM, since the signal quality will get impacted by leakage in the Fast Fourier Transform (FFT), due to, for instance, the doppler shift from UE signals.

[0143] In another example, the signals S1, S2 or S3 could be configured with different carriers. In this way, an additional channel filter could be applied. As such, an additional selectivity can be achieved to reduce the high PSD signal interference to a low PSD signal.

[0144] In another example, the receiving IAB node may apply techniques to reduce or cancel out interference, e.g., by performing successive interference cancellation on the received signals, a procedure known in the art. If the interference is not too strong such that the dynamic range in the receiver is exceeded, the received signal will contain both the signal and interferer within the received signal. By further using a mathematical model of the interference, it is possible to first decode the stronger signal and in a second step, recreate the interference arising from the decoded signal and to remove it from the weaker signal.

[0145] Based on the above, method 100 can further comprise the following steps:

[0146] In some examples, the IAB node may configure a high power level signal and a low power level signal in different carriers, for mitigating noise interference or interference, when receiving the high power level signal and the low power level signal.

[0147] In some examples, the IAB node may apply a digital filter when receiving a high power level signal and a low power level signal for mitigating noise interference or interference.

[0148] In some examples, the IAB node may apply successive interference cancellation on a received high power level signal and low power level signal for mitigating noise interference or interference.

[0149] A method for reducing PSD in signals received at a network node may comprise the following set of steps:

[0150] - Receiving a signal containing at least two frequency multiplexed signals from at least two transmitters;

[0151] - Decoding one of the at least two frequency-domain-multiplexed signals;

[0152] - Determining and subtracting interference from the decoded signal on the at least one remaining signals;

[0153] - Decoding the at least one remaining signals.

[0154] It should be noted that a step can be added in this method in which the interference of the neighboring signal on the remaining signal is modeled.

[0155] PSD interference minimization through scheduling

[0156] In an example, to mitigate PSD interference, signals could be arranged such that a signal that is deemed to suffer less from PSD is arranged in closer proximity to the interferer compared to a signal that is deemed to suffer more. In Figure 3, S2 interference with S1 may be more problematic compared to S2 interference with S3, due to the larger dynamic range between S1 and S2. Hence, a more preferable configuration would be S2 – S3 – S1, allowing the IAB node to maintain receiving S1. The new configuration relates to the power levels of the different signals as presented in Figure 3. The configuration clearly shows that the strongest and weakest signals should not be put next to each other. Assuming the new ordering/configuration, the interference that is introduced from S3 on S2 and possibly also from S2 on S1 will further require a change in, e.g., Modulation Coding Scheme (MCS) for the weaker signals. Hence, a method for reducing PSD interference through scheduling may comprise the following steps:

[0157] - Determining an interference level from all transmitters;

[0158] - Arranging at least one of the transmitters spectrum-wise in a preferred way with regards to interference;

[0159] - Determining a compensation factor for at least one of the transmitters due to other simultaneous interfering transmitters.

[0160] Furthermore, with reference to Figure 3, the DU will receive UL backhaul (S2) and UE UL (S3) simultaneously with the MT receiving DL backhaul (S1). Assuming one receiver, where the S1, S2 and S3 are handled by the same analog frontend and Digital Signal Processing (DSP) and where the separation into downlink and uplink frames are done in the software, a large difference in the PSD level will cause interference such that the information in the interfered signal might be unable to be decoded. In order to estimate the differences in the PSD levels between the signals, the existing different reference signals can be used if they are time scheduled so that they not are received at the same time. More specifically, the DU can estimate P1, the PSD of S1, by activating the measuring function when the MT is supposed to receive the Synchronization Signal Block (SSB)/Physical Broadcast Channel (PBCH) or Channel State information – Reference Signal (CSI-RS) on the backhaul downlink from the parent DU. During this measurement, the DU should not schedule any uplink (i.e. during the measurement period). The DU can request sounding reference signal (SRS) from the child MT and measures P2, the PSD of S2. The parent DU should not transmit in downlink during the SRS measurement and not schedule any UL from the UE. The DU request the SRS from the child MT and measures P3, the PSD of S3. The parent DU should not transmit in downlink during the SRS measurement and not schedule any UL from the MT. The different PSDs (P1, P2 and P3) can be further processed as described in the previous examples, i.e. calculating the difference between P1, P2 and P3, etc.

[0161] An example of method for mitigating noise interference/interference from a high power level signal to a low power level signal of simultaneous reception of different signals will be described below. The method comprises performing one or more of the following: a) Configuring the high power level and low level signals in different carriers; b) Applying a digital filter; c) Applying successive interference cancellation on the received signals.

[0162] Now turning to Figure 7, a method 200 in a first network node, such as a target node (e.g. IAB donor node or a parent IAB node, or a base station) will be described. Method 200 may be implemented in network node (or IAB node) 320 of Figure 8. Method 200 comprises:

[0163] Step 210: receiving information about a power level difference for one or more pairs of signals, from a second network node;

[0164] Step 220: comparing the received power level difference to a threshold; and

[0165] Step 230: based on the comparison, sending an adjustment configuration of one or more of transmission and reception parameters of the second network node.

[0166] For example, the second network node may be an IAB node, such as the IAB node of Figure 1. In case power level differences are pre-defined, the power level differences are associated with respective identifiers (IDs). In this case, the first network node may receive the IDs or any other information related to the power level difference.

[0167] In some examples, the first network node may receive a power spectral density (PSD) difference for the one or more pairs of signals, from the second network node.

[0168] In some examples, if the PSD difference is superior to the threshold, the adjustment of the one or more of transmission and reception parameters may comprise: adjusting an antenna array size of a transmitter or receiver of the second network node, adjusting a beam shape of a transmitter or a receiver of the second network node, decreasing an output power of a transmitter of the second network node, or applying different beamforming for two signals, a high power level signal and a low power signal, received simultaneously at the second network node.

[0169] Figure 8 illustrates an example of a wireless network 300 that may be used for wireless communications. Wireless network 300 includes UEs 310 and a plurality of radio network nodes 320 (e.g., Node Bs (NBs) Radio Network Controllers (RNCs), evolved NBs (eNBs), next generation NB (gNBs), etc.) directly or indirectly connected to a core network 330 which may comprise various core network nodes. The network 300 may use any suitable radio access network (RAN) deployment scenarios, including Universal Mobile Telecommunication System (UMTS) Terrestrial Radio Access Network (UTRAN), and Evolved UMTS Terrestrial Radio Access Network (EUTRAN). UEs 310 may be capable of communicating directly with radio network nodes 320 over a wireless interface. In certain embodiments, UEs may also be capable of communicating with each other via device-to-device (D2D) communication. In certain embodiments, network nodes 320 may also be capable of communicating with each other, e.g. via an interface (e.g. X2 in LTE or other suitable interface).

[0170] As an example, UE 310 may communicate with radio network node 320 over a wireless interface. That is, UE 310 may transmit wireless signals to and/or receive wireless signals from radio network node 320. The wireless signals may contain voice traffic, data traffic, control signals, and/or any other suitable information. In some embodiments, an area of wireless signal coverage associated with a radio network node 320 may be referred to as a cell.

[0171] It should be noted that a UE may be a wireless device, a radio communication device, target device, device to device (D2D) UE, machine type UE or UE capable of machine to machine communication (M2M), a sensor equipped with UE, iPAD, Tablet, mobile terminals, smart phone, laptop embedded equipped (LEE), laptop mounted equipment (LME), Universal Serial Bus (USB) dongles, Customer Premises Equipment (CPE) etc.

[0172] In some embodiments, the “network node” can be any kind of network node which may comprise of a radio network node such as a radio access node (which can include a base station, radio base station, base transceiver station, base station controller, network controller, gNB, NR BS, evolved Node B (eNB), Node B, Multi-cell/multicast Coordination Entity (MCE), relay node, access point, radio access point, Remote Radio Unit (RRU), Remote Radio Head (RRH), a multi-standard BS (also known as MSR BS), etc.), a core network node (e.g., MME, SON node, a coordinating node, positioning node, MDT node, etc.), or even an external node (e.g., 3rd party node, a node external to the current network), etc. The network node may also comprise a test equipment. The network node 320 may be an IAB node, a child IAB node, a parent IAB node or a IAB donor. Furthermore, the IAB node 320 nay have components as a MT and/or DU (as illustrated in Figures 2A and 2B).

[0173] In certain embodiments, network nodes 320 may interface with a radio network controller (not shown). The radio network controller may control network nodes 320 and may provide certain radio resource management functions, mobility management functions, and/or other suitable functions. In certain embodiments, the functions of the radio network controller may be included in the network node 320. The radio network controller may interface with the core network node 340. In certain embodiments, the radio network controller may interface with the core network node 340 via the interconnecting network 330.

[0174] The interconnecting network 330 may refer to any interconnecting system capable of transmitting audio, video, signals, data, messages, or any combination of the preceding. The interconnecting network 330 may include all or a portion of a public switched telephone network (PSTN), a public or private data network, a local area network (LAN), a metropolitan area network (MAN), a wide area network (WAN), a local, regional, or global communication or computer network such as the Internet, a wireline or wireless network, an enterprise intranet, or any other suitable communication link, including combinations thereof.

[0175] In some embodiments, the core network node 340 may manage the establishment of communication sessions and various other functionalities for wireless devices 310. Examples of core network node 340 may include MSC, MME, SGW, PGW, O&M, OSS, SON, positioning node (e.g. E-SMLC), MDT node, etc. Wireless devices 110 may exchange certain signals with the core network node 340 using the non-access stratum layer. In non-access stratum signaling, signals between wireless devices 310 and the core network node 340 may be transparently passed through the radio access network. In certain embodiments, network nodes 320 may interface with one or more other network nodes over an internode interface. For example, network nodes 320 may interface each other over an X2 interface.

[0176] Although Figure 8 illustrates a particular arrangement of network 300, the present disclosure contemplates that the various embodiments described herein may be applied to a variety of networks having any suitable configuration. For example, network 300 may include any suitable number of wireless devices 310 and network nodes 320, as well as any additional elements suitable to support communication between wireless devices or between a wireless device and another communication device (such as a landline telephone). The embodiments may be implemented in any appropriate type of telecommunication system supporting any suitable communication standards and using any suitable components and are applicable to any radio access technology (RAT) or multi-RAT systems in which the wireless device receives and/or transmits signals (e.g., data). While certain embodiments are described for NR and/or LTE, the embodiments may be applicable to any RAT, such as UTRA, E-UTRA, narrow band internet of things (NB-IoT), WiFi, Bluetooth, next generation RAT (NR, NX), 4G, 5G, LTE FDD/TDD, etc. Furthermore, the communication system 300 may itself be connected to a host computer (see

Figure 20 for example). The network 300 (with the wireless devices 310 and network nodes 320) may be able to operate in LAA or unlicensed spectrum.

[0177] Figure 9 is a schematic block diagram of the wireless device 310 according to some embodiments of the present disclosure. As illustrated, the wireless device 310 includes circuitry 400 comprising one or more processors 410 (e.g., Central Processing Units (CPUs), Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), and/or the like) and memory 420. The wireless device 310 also includes one or more transceivers 430 each including one or more transmitters 440 and one or more receivers 450 coupled to one or more antennas 460. Furthermore, the processing circuitry 400 may be connected to an input interface 480 and an output interface 485. The input interface 480 and the output interface 485 may be referred to as communication interfaces. The wireless device 310 may further comprise power source 490.

[0178] In some embodiments, the functionality of the wireless device 310 described above may be fully or partially implemented in software that is, e.g., stored in the memory 420 and executed by the processor(s) 410. For example, the processor 410 is configured to perform all the functionalities performed by the wireless device 310.

[0179] In some embodiments, a computer program including instructions which, when executed by the at least one processor 410, causes the at least one processor 410 to carry out the functionality of the wireless device 310 according to any of the embodiments described herein is provided. In some embodiments, a carrier containing the aforementioned computer program product is provided. The carrier is one of an electronic signal, an optical signal, a radio signal, or a computer readable storage medium (e.g., a non-transitory computer readable medium such as memory).

[0180] Figure 10 is a schematic block diagram of the wireless device 310 according to some other embodiments of the present disclosure. The wireless device 310 includes one or more modules 495, each of which is implemented in software. The module(s) 495 provide the functionality of the wireless device 310 described herein.

[0181] Figure 11 is a schematic block diagram of a network node 320 according to some embodiments of the present disclosure. As illustrated, the network node 320 includes a processing circuitry 500 comprising one or more processors 510 (e.g., CPUs, ASICs, FPGAs, and/or the like) and memory 520. The network node also comprises a network interface 530. The network node 320 also includes one or more transceivers 540 that each include one or more transmitters 550 and one or more receivers 560 coupled to one or more antennas 570. In some embodiments, the functionality of the network node 320 described above may be fully or partially implemented in software that is, e.g., stored in the memory 520 and executed by the processor(s) 510. For example, the processor 510 can be configured to perform any steps of the methods 100 and 200 of Figures 6 and 7 respectively.

[0182] Figure 12 is a schematic block diagram of the network node 320 according to some other embodiments of the present disclosure. The network node 320 includes one or more modules 580, each of which is implemented in software. The module(s) 580 provide the functionality of the network node 320 described herein. The module(s) 580 may comprise, for example, a determining module operable to perform steps 110 and 120 of Figure 6, a sending/transmitting module operable to perform step 130 of Figure 6 and step 230 of Figure 7, an adjusting module operable to perform 130 of Figure 6 a comparing module operable to perform step 220 of Figure 7, and a receiving module operable to perform 210 of Figure 7.

[0183] Figure 13 is a schematic block diagram that illustrates a virtualized embodiment of the wireless device 310 or network node 320, according to some embodiments of the present disclosure. As used herein, a “virtualized” node 1200 is a network node 320 or wireless device 310 in which at least a portion of the functionality of the network node 320 or wireless device 310 is implemented as a virtual component (e.g., via a virtual machine(s) executing on a physical processing node(s) in a network(s)). For example, in Figure 13, there is provided an instance or a virtual appliance 1220 implementing the methods or parts of the methods of some embodiments. The one or more instance(s) runs in a cloud computing environment 1200. The cloud computing environment provides processing circuits 1230 and memory 1290-1 for the one or more instance(s) or virtual applications 1220. The memory 1290-1 contains instructions 1295 executable by the processing circuit 1260 whereby the instance 1220 is operative to execute the methods or part of the methods described herein in relation to some embodiments.

[0184] The cloud computing environment 1200 comprises one or more general-purpose network devices including hardware 1230 comprising a set of one or more processor(s) or processing circuits 1260, which may be commercial off-the-shelf (COTS) processors, dedicated Application Specific Integrated Circuits (ASICs), or any other type of processing circuit including digital or analog hardware components or special purpose processors, and network interface controller(s) (NICs) 1270, also known as network interface cards, which include physical Network Interface 1280. The general-purpose network device also includes non-transitory machine readable storage media 1290-2 having stored therein software and/or instructions 1295 executable by the processor 1260. During operation, the processor(s)/processing circuits 1260 execute the software/instructions 1295 to instantiate a hypervisor 1250, sometimes referred to as a virtual machine monitor (VMM), and one or more virtual machines 1240 that are run by the hypervisor 1250.

[0185] A virtual machine 1240 is a software implementation of a physical machine that runs programs as if they were executing on a physical, non-virtualized machine; and applications generally do not know they are running on a virtual machine as opposed to running on a “bare metal” host electronic device, though some systems provide para-virtualization which allows an operating system or application to be aware of the presence of virtualization for optimization purposes. Each of the virtual machines 1240, and that part of the hardware 1230 that executes that virtual machine 1240, be it hardware 1230 dedicated to that virtual machine 1240 and/or time slices of hardware 1230 temporally shared by that virtual machine 1240 with others of the virtual machine(s) 1240, forms a separate virtual network element(s) (VNE).

[0186] The hypervisor 1250 may present a virtual operating platform that appears like networking hardware to virtual machine 1240, and the virtual machine 1240 may be used to implement functionality such as control communication and configuration module(s) and forwarding table(s), this virtualization of the hardware is sometimes referred to as network function virtualization (NFV). Thus, NFV may be used to consolidate many network equipment types onto industry standard high volume server hardware, physical switches, and physical storage, which can be located in Data centers, and customer premise equipment (CPE). Different embodiments of the instance or virtual application 1220 may be implemented on one or more of the virtual machine(s) 1240, and the implementations may be made differently.

[0187] In some embodiments, a carrier comprising the aforementioned computer program product is provided. The carrier is one of an electronic signal, an optical signal, a radio signal, or a computer readable storage medium (e.g., a non-transitory computer readable medium such as memory).

[0188] Some embodiments may be represented as a non-transitory software product stored in a machine-readable medium (also referred to as a computer-readable medium, a processor-readable medium, or a computer usable medium having a computer readable program code embodied therein). The machine-readable medium may be any suitable tangible medium including a magnetic, optical, or electrical storage medium including a diskette, compact disk read only memory (CD-ROM), digital versatile disc read only memory (DVD-ROM) memory device (volatile or non-volatile), or similar storage mechanism. The machine-readable medium may contain various sets of instructions, code sequences, configuration information, or other data, which, when executed, cause a processor to perform steps in a method according to one or more of the described embodiments. Those of ordinary skill in the art will appreciate that other instructions and operations necessary to implement the described embodiments may also be stored on the machine-readable medium. Software running from the machine-readable medium may interface with circuitry to perform the described tasks.

[0189] The above-described embodiments are intended to be examples only. Alterations, modifications and variations may be effected to the particular embodiments by those of skill in the art without departing from the scope of the description, which is defined solely by the appended claims.

Claims

What is claimed is:

1. A method in an Integrated Access Backhaul (IAB) network for simultaneous reception of different signals from different cells or the same cell at an IAB node, the method comprising:
    - determining a power level difference for one or more pairs of received signals;
    - determining if the power level difference of one or more pairs of the received signals is within a range of power levels; and
    - in response to determining that the power level difference is not within the range, performing one or more of: adjusting one or more of transmission and reception parameters for one of transmitting and receiving signals, and, transmitting information about the power level difference to a network node.
2. The method of claim 1, further comprising determining a power level for each received signal.
3. The method of claim 1 or 2, further comprising, in response to determining that the power level difference of a pair of received signals is within the power range, configuring a receiver of the IAB node for simultaneously receiving the pair of signals.
4. The method of any one of claims 1 to 3, further comprising obtaining the range of power levels from a local IAB node.
5. The method of claim 4, further comprising reporting the range of power levels to a co-ordination unit.
6. The method of any one of claims 1 to 5, wherein a command of the adjustment of the one or more of transmission and reception parameters is sent to a coordination unit.
7. The method of claim 6, wherein the coordination unit is in either a local IAB node or remotely.
8. The method of any one of claims 1 to 7, wherein adjusting one or more of transmission and reception parameters comprises adjusting an antenna array size of a transmitter or a receiver.
9. The method of any one of claims 1 to 7, wherein adjusting one or more of transmission and reception parameters comprises adjusting a beam shape of a transmitter or a receiver.

10. The method of any one of claims 1 to 7, wherein adjusting the transmission parameters comprises decreasing an output power of a transmitter.

11. The method of any one of claims 1 to 7, wherein adjusting the reception parameters comprises applying different beamforming for two simultaneously received high power level signal and low power signal.

12. The method of claim 1, wherein determining a power level difference for one or more pairs of received signals comprises determining a power spectrum density (PSD) difference of the one or more pairs of signals.

13. The method of claim 12, further comprising sending information related to the PSD difference of the one or more pairs of signals to a target node.

14. The method of claim 12 or 13, wherein determining the PSD difference comprises determining the PSD difference for a configured duration.

15. The method of any one of claims 13 to 14, wherein sending the information related to the PSD difference comprises sending the information periodically or based on an event.

16. The method of claim 15, wherein the event comprises a comparison of the determined PSD difference with a threshold.

17. The method of any one of claims 12 to 16, further comprising, in response to sending the information, receiving a configuration related to receiving subsequent signals.

18. The method of any one of claims 12 to 17, wherein determining the PSD difference comprises determining the PSD difference jointly with cross chain interference (CCI) measurements and cross link interference (CLI) measurements.

19. The method of any one of claims 13 to 18, wherein sending the information related to the PSD difference comprises sending the information in one of a Radio Resource Control (RRC) message, a F1 AP message, in a Medium Access control (MAC) Control Element (CE) message, and a Backhaul Adaptation protocol (BAP) control message.

20. The method of any one of claims 13 to 19, wherein the information related to the PSD difference comprises one or more of a value of the PSD difference, information about a type of PSD difference, information about signals whose PSD difference is estimated for triggering an event or for periodic reporting, a duration over which the PSD difference is estimated, and a range of PSD.

21. The method of claim 1, further comprising configuring a high power level signal and a low power level signal in different carriers, for mitigating interference, when receiving the high power level signal and the low power level signal.

22. The method of claim 1, further comprising applying a digital filter when receiving a high power level signal and a low power level signal for mitigating interference.

23. The method of claim 1, further comprising applying successive interference cancellation on a received high power level signal and low power level signal for mitigating interference.

24. The method of claim 2, further comprising arranging received signals in an order based on the determined power level.

25. A method in a first network node, the method comprising:
    - receiving information about a power level difference for one or more pairs of signals, from a second network node;
    - comparing the received power level difference to a threshold; and
    - based on the comparison, sending an adjustment configuration of one or more of transmission and reception parameters of the second network node, to the second network node.

26. The method of claim 25, further comprising receiving a power spectral density (PSD) difference for the one or more pairs of signals, from the second network node.

27. The method of claim 26, wherein, if the PSD difference is superior to the threshold, the adjustment of one of transmission and reception parameters comprises adjusting an antenna array size of a transmitter or receiver of the second network node.

28. The method of claim 26, wherein, if the PSD difference is superior to the threshold, the adjustment of one or more of transmission and reception parameters comprises adjusting a beam shape of a transmitter or a receiver of the second network node.

29. The method of claim 26, wherein, if the PSD difference is superior to the threshold, the adjustment of one or more of transmission and reception parameters comprises decreasing an output power of a transmitter of the second network node.

30. The method of claim 26, wherein, if the PSD difference is superior to the threshold, the adjustment of one or more of transmission and reception parameters comprises applying different beamforming for two signals, a high power level signal and a low power signal, received simultaneously at the second network node.

31. A network node comprising a communication interface and processing circuitry connected thereto and configured to perform any of the methods of embodiments 1 to 30.

32. A computer program product comprising a non-transitory computer readable storage medium having computer readable program code embodied in the medium, the computer readable program code comprising computer readable program code to operate according to any of the methods of embodiments 1 to 30.

33. A network node configured to communicate with a base station and a UE comprising a radio interface and processing circuitry configured to perform any of the steps of any of embodiments 1 to 30.

34. A base station configured to communicate with a user equipment (UE), the base station comprising a radio interface and processing circuitry configured to perform any of the methods of embodiments 1 to 30.

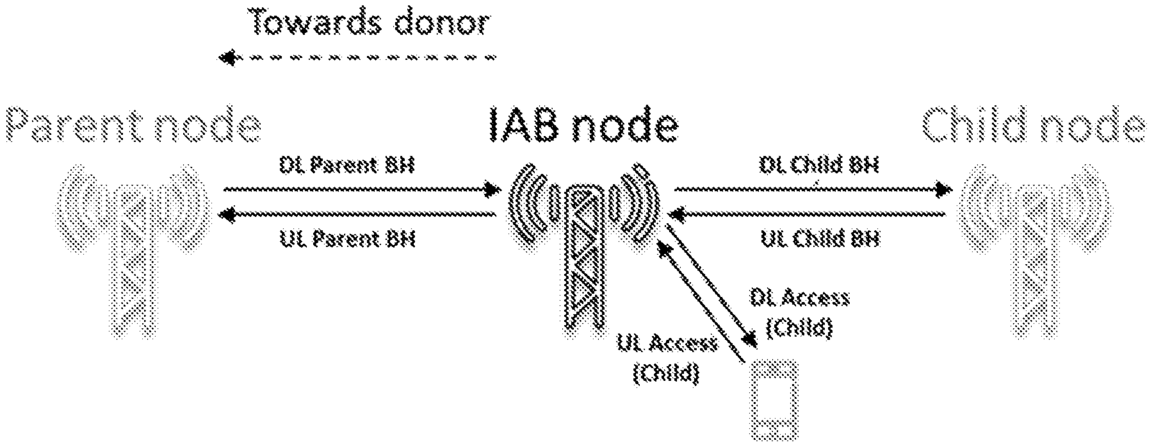


Figure 1

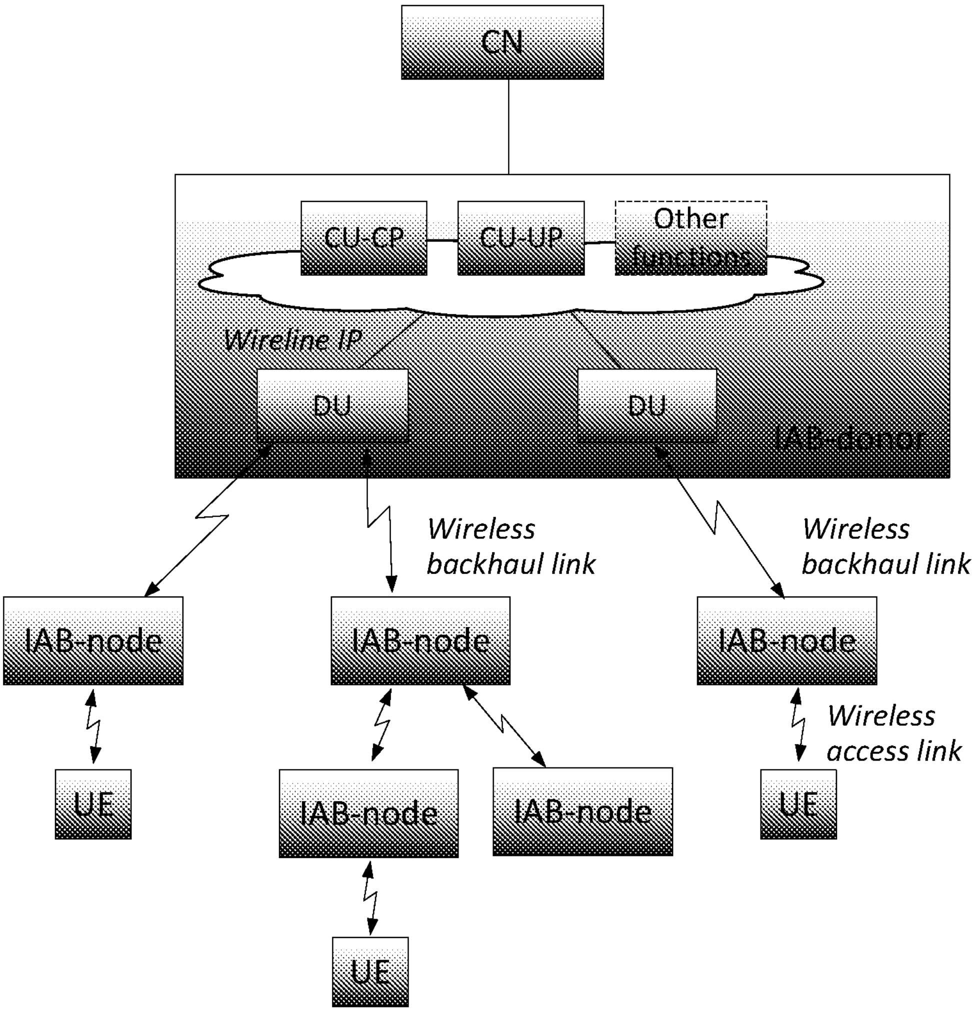


Figure 2A

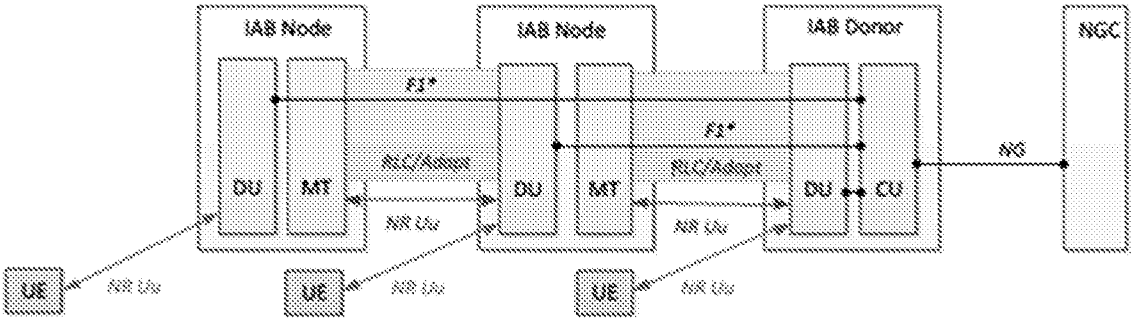


Figure 2B

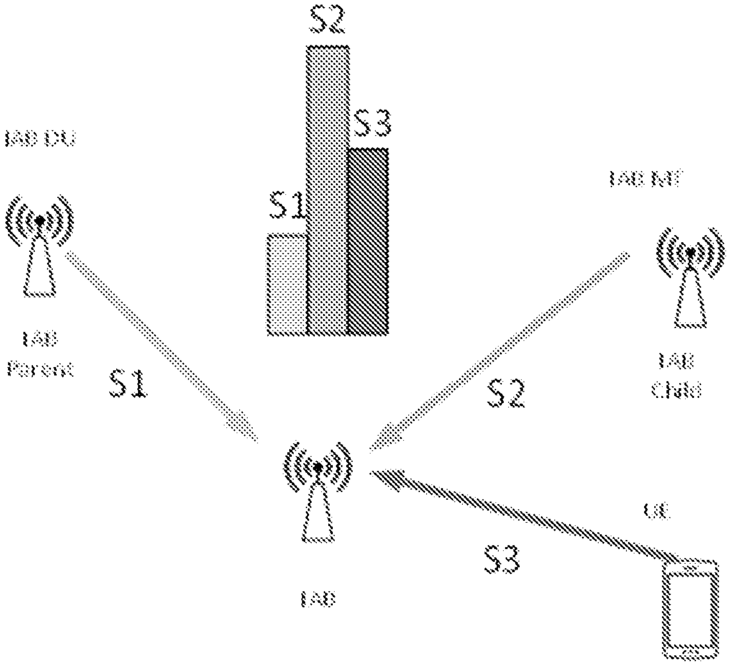


Figure 3

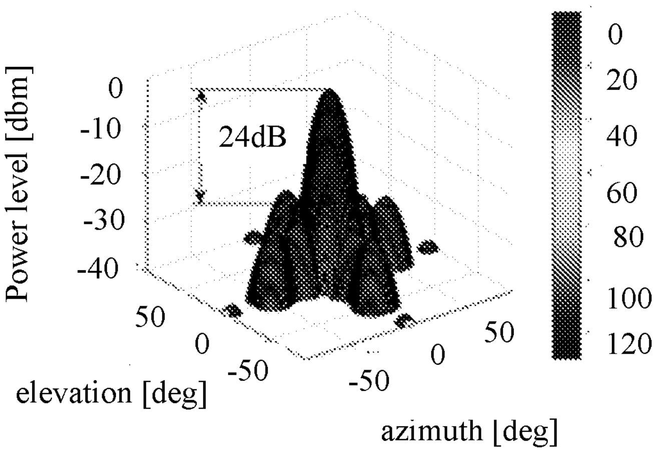


Figure 4

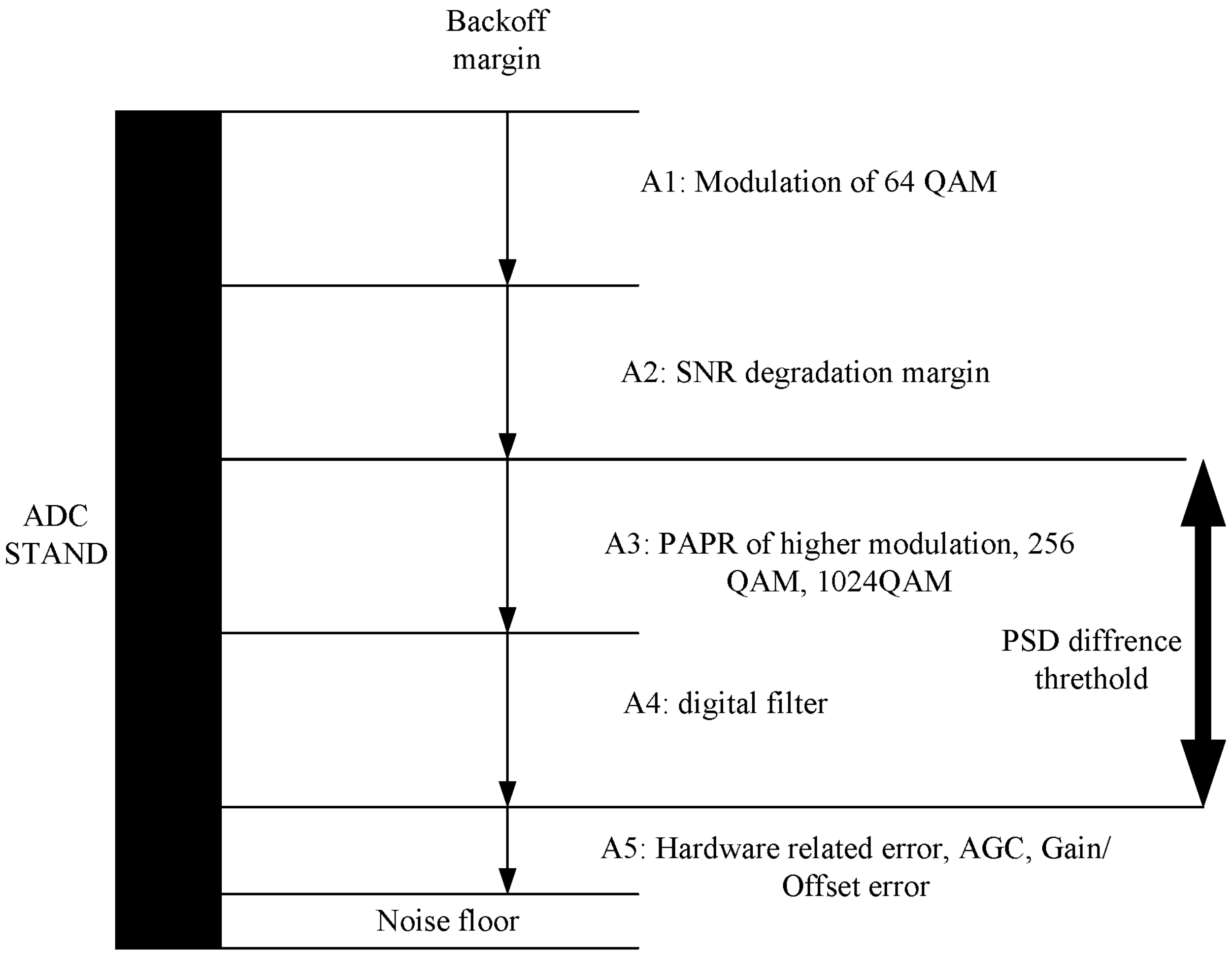


Figure 5

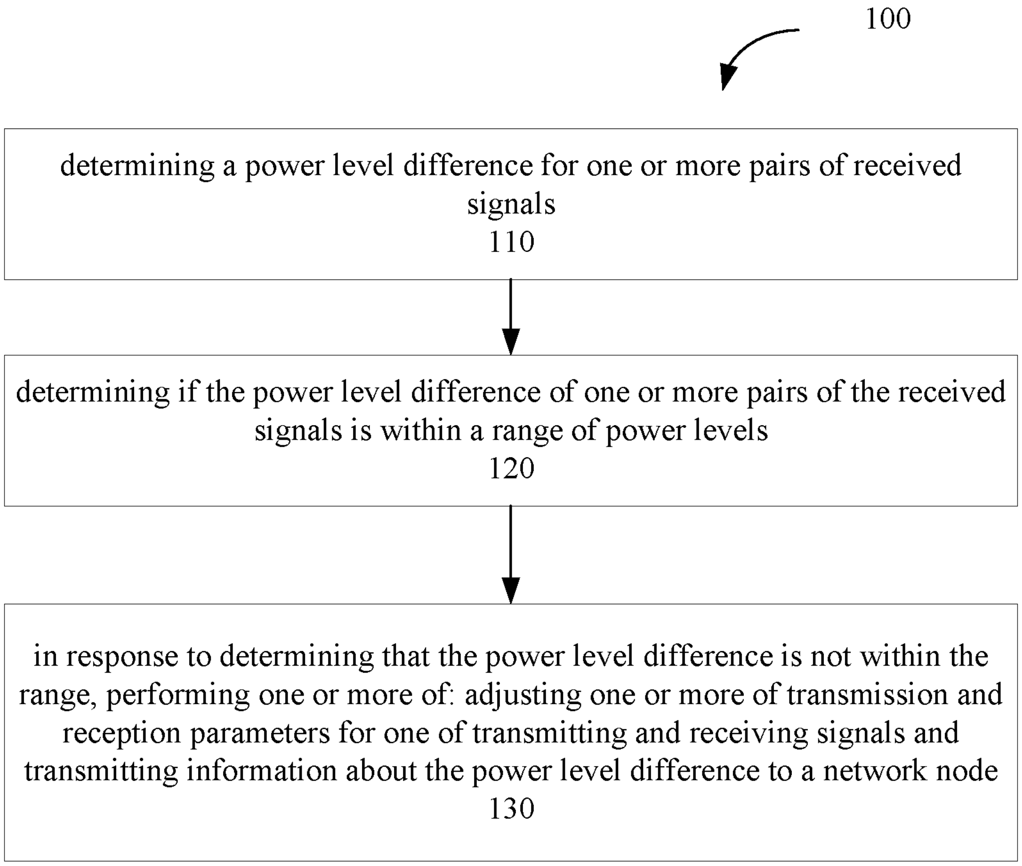
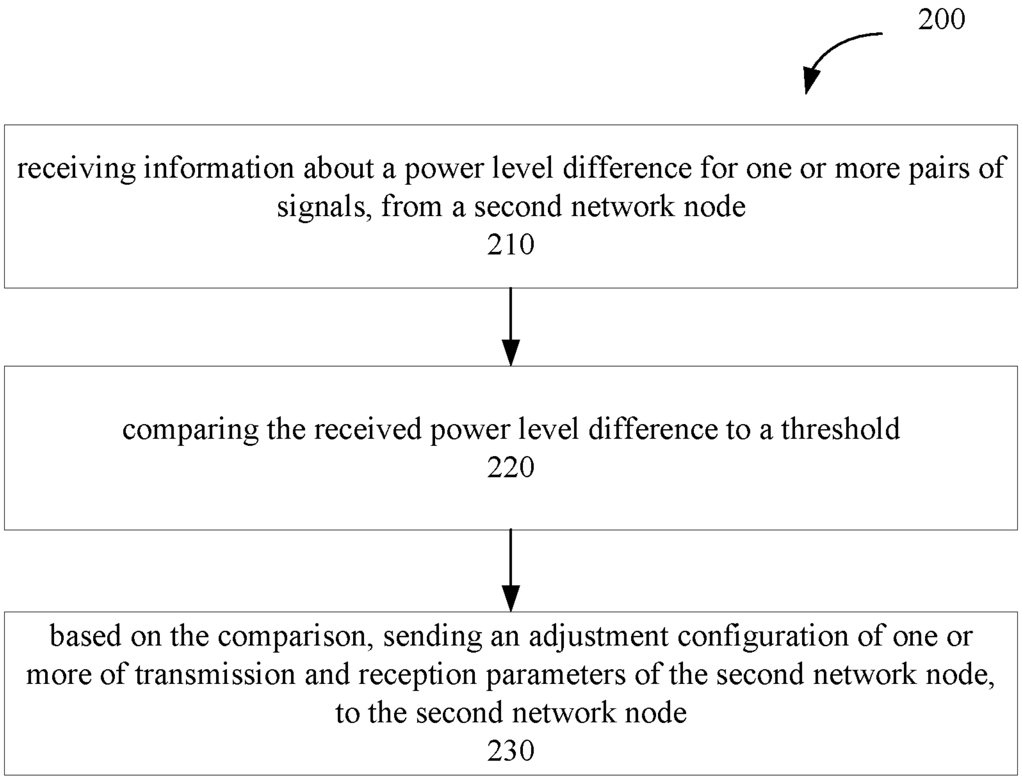


Figure 6



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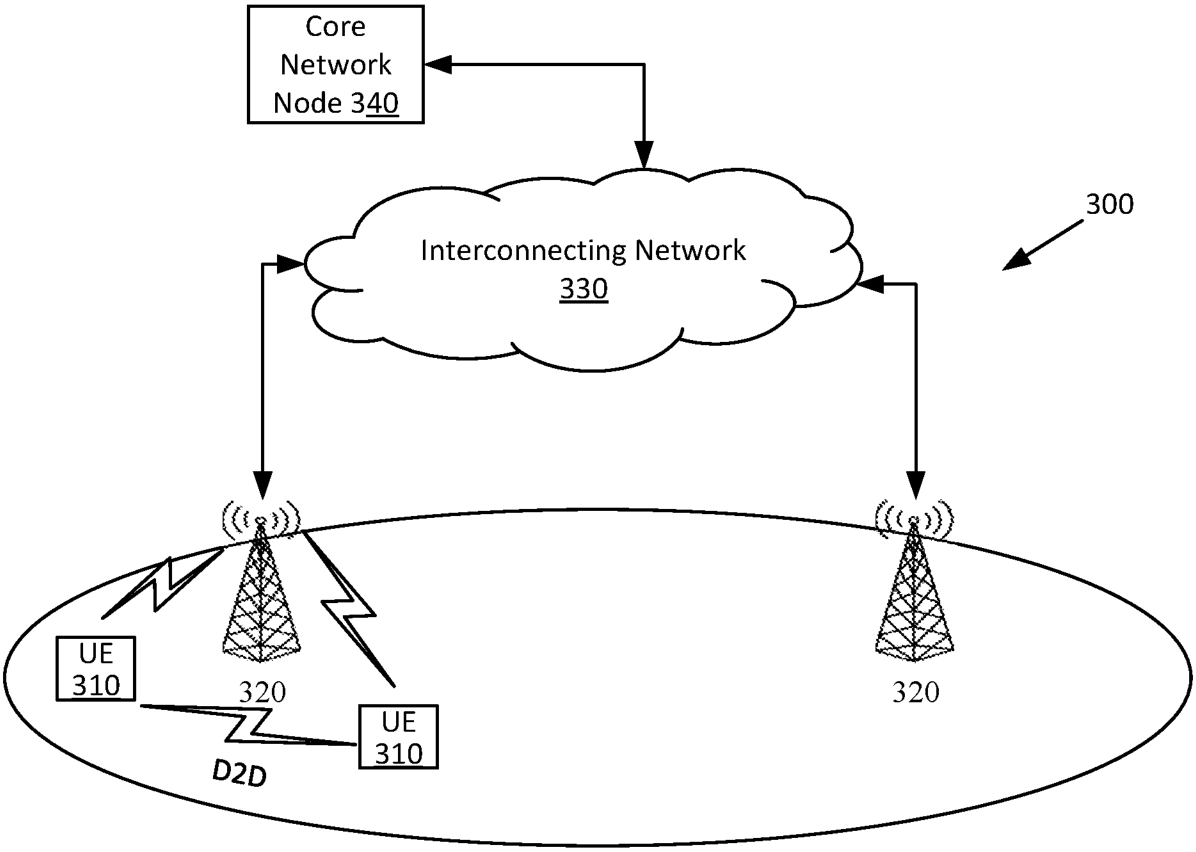
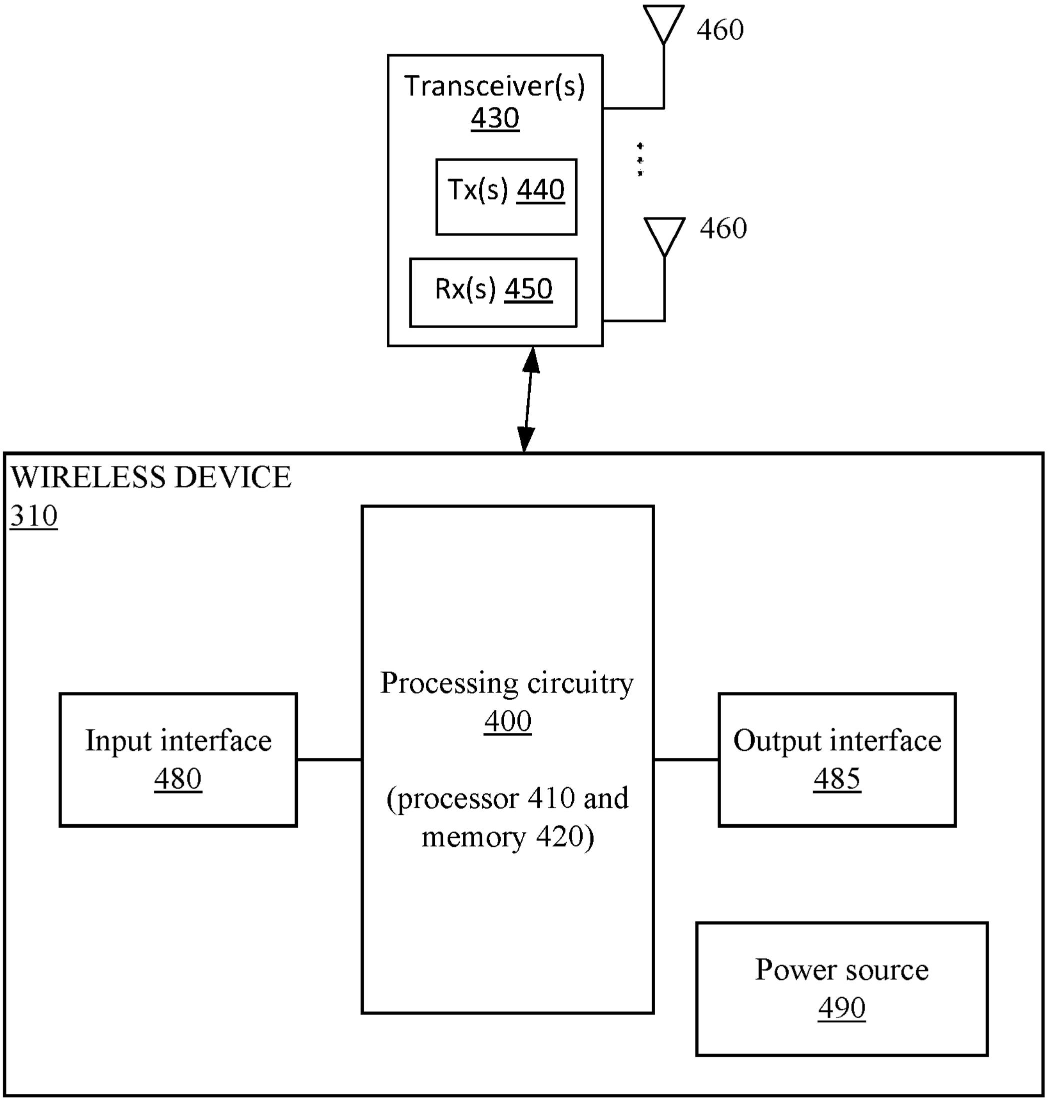

Core Network Node 340
Interconnecting Network 330
300
UE 310
320
UE 310
D2D
320

Figure 8



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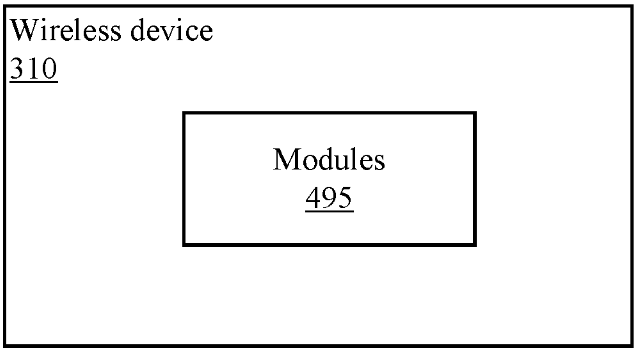

Figure 10

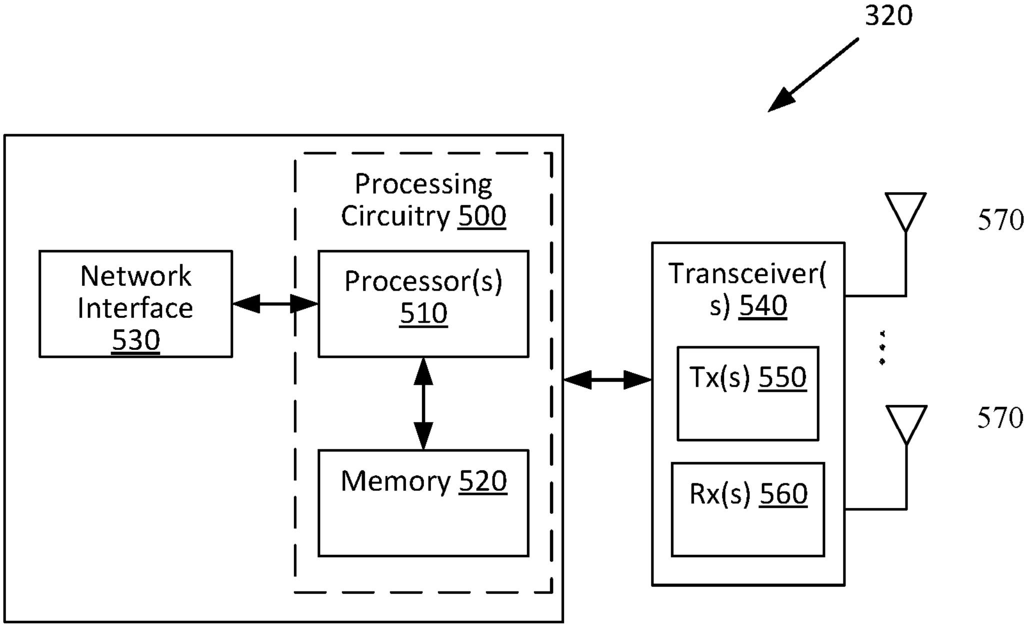

Figure 11

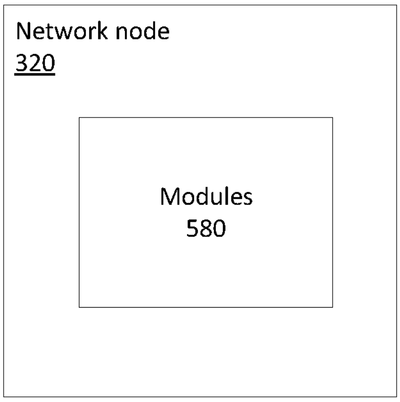

Figure 12

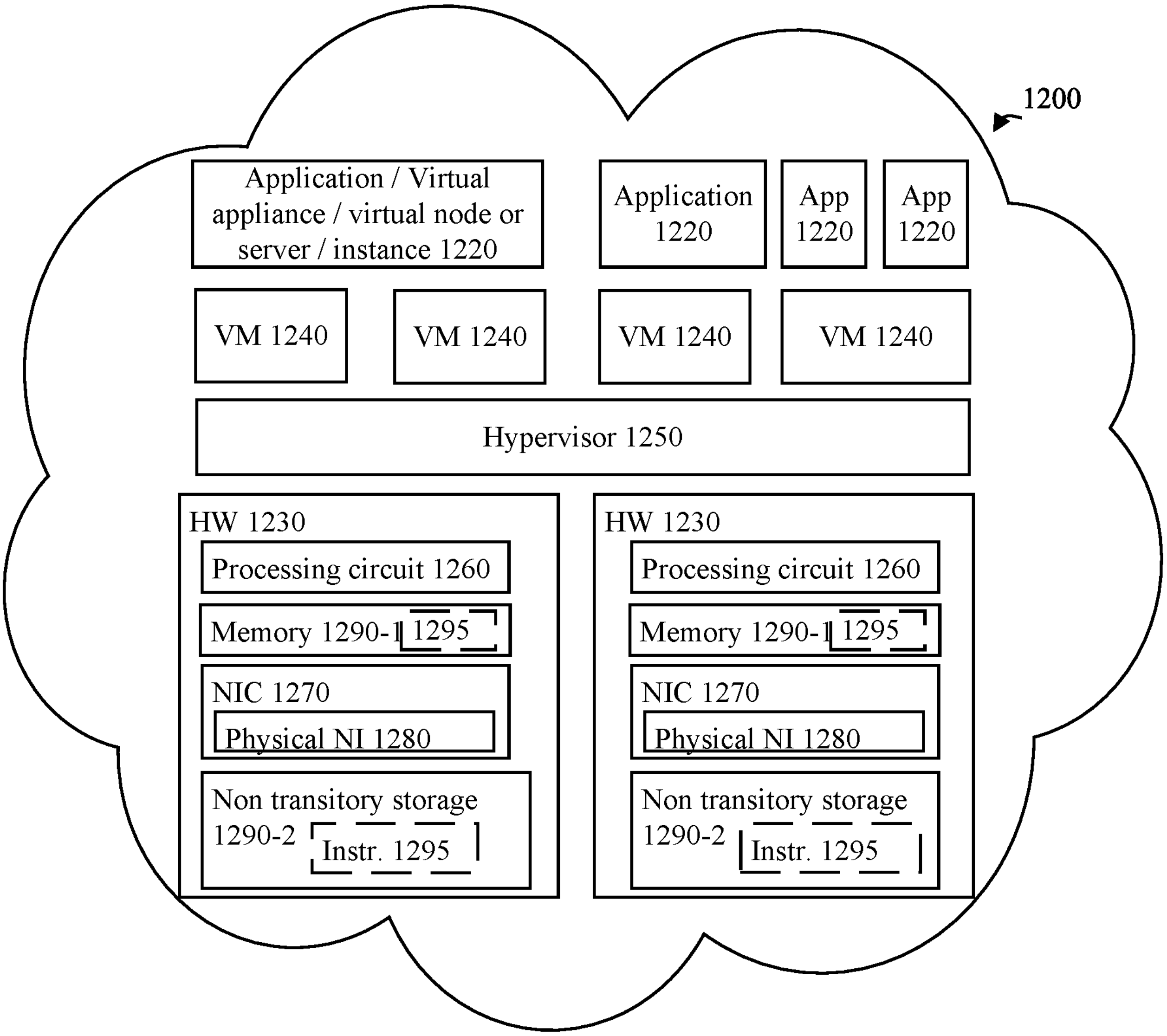
1200
Application / Virtual appliance / virtual node or server / instance 1220
Application 1220
App 1220
App 1220
VM 1240
VM 1240
VM 1240
VM 1240
Hypervisor 1250
HW 1230
Processing circuit 1260
Memory 1290-1
1295
NIC 1270
Physical NI 1280
Non transitory storage 1290-2
Instr. 1295
HW 1230
Processing circuit 1260
Memory 1290-1
1295
NIC 1270
Physical NI 1280
Non transitory storage 1290-2
Instr. 1295

Figure 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2021/051205

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W52/04 H04W52/36 H04W52/06 H04W52/08 H04W52/10
H04W52/12 H04W52/14 H04W52/24
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2020/045645 A1 (CHOPRA ADITYA [US] ET AL) 6 February 2020 (2020-02-06)	1-3,10, 12-17, 19-21, 24-26, 29-34
Y	paragraph [0019] paragraph [0028] paragraphs [0031], [0034], [0036], [0037] - [0039] paragraph [0045] paragraph [0054] -----	4-9,11, 18,22, 23,27,28
Y	US 2020/045563 A1 (LUO JIANGHONG [US] ET AL) 6 February 2020 (2020-02-06) paragraph [0059] ----- -/--	4-7

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search 30 April 2021	Date of mailing of the international search report 11/05/2021
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 Mele, Marco

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2021/051205

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 10 470 136 B1 (GHOSH ARUNABHA [US] ET AL) 5 November 2019 (2019-11-05) column 11, line 11 - line 25 -----	18

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

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Information on patent family members

International application No
PCT/IB2021/051205

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