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(54) Title: NETWORK NODE AND METHOD IN A WIRELESS COMMUNICATIONS NETWORK

(57) Abstract: A method performed by a network node for performing an uplink antenna calibration of an antenna system of the network node is provided. The antenna system comprises multiple branches, wherein each branch out of the multiple of branches is associated with a respective Uplink (UL) link. The network node is operating in a wireless communications network. For each respective UL link: The network node receives (302) a number of subsequent symbols from an Antenna Interface (AI) transceiver of the antenna system. The symbols are Orthogonal Frequency Division Multiplex (OFDM) symbols. When a current received symbol is received after one or more previous received symbols of out of the received symbols, the network node accumulates (304) the current received symbol and the one or more previous received symbols. When the signal quality value of the accumulated received symbols is smaller than a signal quality value of a symbol received previous of the current received symbol, the network node discards (307) the current received symbol, and when the signal quality value of the accumulated received symbols is larger than a signal quality value of a symbol received previous of the current received symbol, the network node sets (308) the signal quality value for the particular branch and its associated UL link to be the accumulated signal quality value.

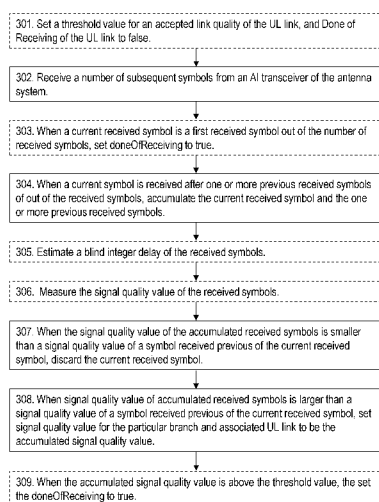


Fig. 3 Method in network node 110

NETWORK NODE AND METHOD IN A WIRELESS COMMUNICATIONS NETWORK

TECHNICAL FIELD

Embodiments herein generally relate to a network node and a method therein. More
5 specifically, they relate to uplink antenna calibration of an antenna system of the network node.

BACKGROUND

In a typical wireless communication network, wireless devices, also known as
10 wireless communication devices, mobile stations, stations (STA) and/or User Equipments (UE), communicate via a Local Area Network such as a Wi-Fi network or a Radio Access Network (RAN) to one or more core networks (CN). The RAN covers a geographical area which is divided into service areas or cell areas, which may also be referred to as a beam or a beam group, with each service area or cell area being served by a radio network
15 node such as a radio access node e.g., a Wi-Fi access point or a radio base station (RBS), which in some networks may also be denoted, for example, a NodeB, eNodeB (eNB), or gNB as denoted in 5G. A service area or cell area is a geographical area where radio coverage is provided by the radio network node. The radio network node communicates over an air interface operating on radio frequencies with the wireless
20 device within range of the radio network node.

Specifications for the Evolved Packet System (EPS), also called a Fourth Generation (4G) network, have been completed within the 3rd Generation Partnership Project (3GPP) and this work continues in the coming 3GPP releases, for example to specify a Fifth Generation (5G) network also referred to as 5G New Radio (NR). The EPS
25 comprises the Evolved Universal Terrestrial Radio Access Network (E-UTRAN), also known as the Long Term Evolution (LTE) radio access network, and the Evolved Packet Core (EPC), also known as System Architecture Evolution (SAE) core network. E-UTRAN/LTE is a variant of a 3GPP radio access network wherein the radio network nodes are directly connected to the EPC core network rather than to RNCs used in 3G
30 networks. In general, in E-UTRAN/LTE the functions of a 3G RNC are distributed between the radio network nodes, e.g. eNodeBs in LTE, and the core network. As such, the RAN of an EPS has an essentially "flat" architecture comprising radio network nodes connected directly to one or more core networks, i.e. they are not connected to RNCs. To

compensate for that, the E-UTRAN specification defines a direct interface between the radio network nodes, this interface being denoted the X2 interface.

Multi-antenna techniques can significantly increase the data rates and reliability of a wireless communication system. The performance is in particular improved if both the transmitter and the receiver are equipped with multiple antennas, which results in a Multiple-Input Multiple-Output (MIMO) communication channel. Such systems and/or related techniques are commonly referred to as MIMO.

3GPP has completed the freeze of 5G Non-Standalone (NSA) specification in March 2018 and 5G Standalone (SA) specification in September 2018. The whole industry is now stepping forward at full speed towards 5G commercialization. Numerous new features are introduced in the 5G NR system, in which, Massive MIMO is the prominent one due to its capability of improvement on spectral efficiency and energy efficiency. Active Antenna System (AAS) is an implementation of massive MIMO, which integrates a Radio Frequency (RF) transceiver and an antenna array to achieve compact size and low power consumption. AAS utilizes beamforming to enlarge the radio coverage, or Multi User (MU)-MIMO to boost the throughput. Antenna arrays and RF links shall be carefully calibrated to ensure that the beam direction or side lobe cancelling is optimized. Therefore, Antenna Calibration (AC) is mandatory for AAS, and its accuracy or robustness directly impacts cellular performance. Generally, AC is composed of uplink AC and downlink AC. In case of uplink AC, Antenna Interface Transceiver (AI-TRX) sends signals to the antenna array and all RX chains retrieve the signal from the antenna array. An Antenna Interface when used herein is a unit that performs distribution of the TX outputs into the corresponding antenna paths and antenna elements, and a distribution of RX inputs from antenna paths in the reverse direction. In case of downlink AC, all TX chains send the signal in different domains to the antenna array and AI-TRX retrieves the signal. TX chain when used herein means a unit that takes the baseband input from the AAS BS and provides the RF TX outputs, and RX chain when used herein means a unit performs the reverse of the TX chain operations.

UL AC may be performed in a Guard Periods (GPs), thanks to the isolation between the antenna array and the AI-TRX.

DL AC is performed in DL slots to comply to 3GPP specification, whereas it occasionally interrupts DL traffic.

UL AC is facing more severe scenarios against DL AC. The major failures of UL AC are caused by external interference. **Figure 1** illustrates interference in one base station BSA from a nearby base station BSB. In a Time Division Duplex (TDD) system, GPs are exploited to protect UL slots from DL signals of neighbor base-stations after channel
5 propagation delay. The length of a GP should be greater than the maximum delay of all surround base-stations, whose configurations are done in network planning. However, UL AC in a GP will destroy this boundary and this will lead to failure. One solution is to redo the network planning, such as changing site position or radiation direction. This work is very high cost and time consuming. Another solution is to add isolation between the
10 antenna array and the RX path in case of UL AC. This work is not realistic due to hardware cost and implementation complexity. Moreover, adding a switch between the antenna and the filter will impact both sensitivity and insertion loss.

15 SUMMARY

Therefore a low cost and easily deployed solution for this issue would be beneficial to network rollout.

An object of embodiments herein is to improve the performance of a wireless
20 communications network using paging.

According to a first aspect of embodiments herein, the object is achieved by a method performed by a network node for performing an uplink antenna calibration of an antenna system of the network node. The antenna system comprises multiple branches,
25 wherein each branch out of the multiple of branches is associated with a respective Uplink, UL, link. The network node is operating in a wireless communications network.

For each respective UL link:

The network node receives a number of subsequent symbols from an Antenna Interface, AI, transceiver of the antenna system. The symbols are Orthogonal Frequency
30 Division Multiplex, OFDM, symbols.

When a current received symbol is received after one or more previous received symbols of out of the received symbols, the network node accumulates the current received symbol and the one or more previous received symbols.

When the signal quality value of the accumulated received symbols is smaller than a signal quality value of a symbol received previous of the current received symbol, the network node discards the current received symbol, and

when the signal quality value of the accumulated received symbols is larger than a
5 signal quality value of a symbol received previous of the current received symbol, the network node sets the signal quality value for the particular branch and its associated UL link to be the accumulated signal quality value.

According to another aspect of embodiments herein, the object is achieved by a
10 network node configured to perform an uplink antenna calibration of an antenna system of the network node. The antenna system is adapted to comprise multiple branches, wherein each branch out of the multiple of branches is adapted to be associated with a respective Uplink, UL, link. The network node is operable in a wireless communications network. The network node 110 is further configured to, for each respective UL link:

15 Receive a number of subsequent symbols from an Antenna Interface, AI, transceiver of the antenna system 112, which symbols are adapted to be Orthogonal Frequency Division Multiplex, OFDM, symbols,

when a current received symbol is received after one or more previous received symbols of out of the received symbols, accumulate the current received symbol and the
20 one or more previous received symbols,

when the signal quality value of the accumulated received symbols is smaller than a signal quality value of a symbol received previous of the current received symbol, discard the current received symbol, and

when the signal quality value of the accumulated received symbols is larger than a
25 signal quality value of a symbol received previous of the current received symbol, set the signal quality value for the particular branch and its associated UL link to be the accumulated signal quality value.

30 BRIEF DESCRIPTION OF THE DRAWINGS

Examples of embodiments herein are described in more detail with reference to attached drawings in which:

Figure 1 is a schematic block diagram illustrating prior art.

- Figure 2 is a schematic block diagram illustrating embodiments of a wireless communications network.
- Figure 3 is a flowchart depicting embodiments of a method in a network node
- Figure 4 is a schematic block diagram illustrating an embodiment herein.
- 5 Figure 5 is a schematic block diagram illustrating an embodiment herein.
- Figure 6 a and b are flowcharts illustrating embodiments of a method.
- Figure 7 is a schematic block diagram illustrating an embodiment herein.
- Figure 8 is a schematic block diagram illustrating an embodiment herein.
- Figure 9 is a schematic diagram illustrating an embodiment herein.
- 10 Figure 10a-b are schematic block diagrams illustrating embodiments of a network node.
- Figure 11 schematically illustrates a telecommunication network connected via an intermediate network to a host computer.
- Figure 12 is a generalized block diagram of a host computer communicating via a base station with a user equipment over a partially wireless connection.
- 15 Figures 13-16 are flowcharts illustrating methods implemented in a communication system including a host computer, a base station and a user equipment.

DETAILED DESCRIPTION

20

Some embodiments herein relate to methods and apparatuses of incremental redundancy based uplink antenna calibration.

Embodiments herein relate to methods for UL AC to unravel the problem caused by
25 external interference. It may e.g. be seen that UL AC looks like broadcast system, i.e. All-TRX in a network node transmits signals to all RX links in the network node simultaneously. Incremental redundancy (IR) is used in the broadcast system to solve inequivalent channel state between receivers such as the RX links aforementioned in AAS. IR is a scheme for soft combining, that is, retransmissions may consist of a different
30 set of coded bits than the original transmission. In embodiments herein, IR is applied to UL AC to improve robustness, efficiency and accuracy. It is confirmed that embodiments herein provide an UL AC that will survive in scenario of external interference.

To utilize IR in UL AC, a set of blind algorithms may also be addressed. These algorithms may comprise blind synchronization and blind SNR estimation, wherein both
35 may be based on Cyclic Prefix (CP). CP when used herein means prefixing of a symbol,

with a repetition of the end. The blind synchronization algorithm may be performed before an AC algorithm. In some embodiments, the AC algorithm will not start until an estimated SNR exceeds a predefined threshold. Therefore, embodiments herein significantly reduce complexity.

- 5 Since estimation accuracy is determined by SNR in the AC algorithm, embodiments herein improve accuracy as well.

Advantages of embodiments herein at least comprise: Improved robustness to external interference, decreased calibration time, low cost of algorithm, enhanced AC
10 accuracy and easy to be combined with today's methods.

Embodiments of the method e.g. comprises: Incremental redundancy in UL AC, scheduling of repeated transmission, blind CP synchronization and blind CP SNR estimation.
15

Embodiments herein relate to wireless communication networks in general. **Figure 2** is a schematic overview depicting a **wireless communications network 100** wherein embodiments herein may be implemented. The wireless communications network 100
20 comprises one or more RANs and one or more CNs. The wireless communications network 100 may use a number of different technologies, such as Wi-Fi, Long Term Evolution (LTE), LTE-Advanced, 5G, New Radio (NR), Wideband Code Division Multiple Access (WCDMA), Global System for Mobile communications/enhanced Data rate for GSM Evolution (GSM/EDGE), Worldwide Interoperability for Microwave Access (WiMax),
25 or Ultra Mobile Broadband (UMB), just to mention a few possible implementations. Embodiments herein relate to recent technology trends that are of particular interest in a 5G context, however, embodiments are also applicable in further development of the existing wireless communication systems such as e.g. WCDMA and LTE.

30 In the wireless communication network 100, wireless devices e.g. **one or more UE 120** such as a mobile station, a non-access point (non-AP) STA, a STA, a user equipment and/or a wireless terminals, communicate via one or more Access Networks (AN), e.g. RAN, to one or more core networks (CN). It should be understood by the skilled in the art that "wireless device" is a non-limiting term which means any terminal, wireless
35 communication terminal, user equipment, Machine Type Communication (MTC) device,

Device to Device (D2D) terminal, or node e.g. smart phone, laptop, mobile phone, sensor, relay, mobile tablets or even a small base station communicating within a cell.

Network nodes operate in the wireless communications network 100 such as a
5 **network node 110** and **neighbouring network node 111**, each network node 110, 111 providing radio coverage over a respective geographical area, a **service area 10**, and a **service area 11**, which may also be referred to as a beams or a beam group. The network nodes 110 and 111 may each be an NG-RAN node, transmission and reception point e.g. a base station, a radio access network node such as a Wireless Local Area
10 Network (WLAN) access point or an Access Point Station (AP STA), an access controller, a base station, e.g. a radio base station such as a NodeB, an evolved Node B (eNB, eNode B), a gNB, a base transceiver station, a radio remote unit, an Access Point Base Station, a base station router, a transmission arrangement of a radio base station, a stand-alone access point or any other network unit capable of communicating with a
15 wireless device within the service area served by the network node 110 and 111 depending e.g. on the first radio access technology and terminology used. The network nodes 110 and 111 may communicate with a UE 120 with Downlink (DL) transmissions to the UE 120 and Uplink (UL) transmissions from the UE 120.

The network node 110 comprises an **antenna system 112**. The **antenna system**
20 112 comprises multiple branches. A **branch** when used herein is a dedicated signal path which provides the signal from AI-TRX to the Base Station (BS) such as the network node 110. Each branch out of the multiple of branches is associated with a respective UL link for UL communication with UEs such as the UE 120. This means that the branch may be configured on respective UL link to enable receiving calibration signal from AI-TRX. The
25 network node 110 and its antenna system 112 are exposed to external interference from the neighbouring network node 111.

Methods herein may be performed by the network node 110. As an alternative, a Distributed Node (DN) and functionality, e.g. comprised in a **cloud 140** as shown in
30 Figure 2, may be used for performing or partly performing the methods.

The above described problem is addressed in a number of embodiments, some of which should be seen as alternatives, while some may be used in combination.

The method will first be described in a general way followed by a more detailed explanation and examples.

Example embodiments of a method performed by the network node 110 for performing an uplink antenna calibration of the antenna system 112 of the network node 110, will now be described with reference to a flowchart depicted in **Figure 3**. As mentioned above, the antenna system 112 comprises multiple branches, wherein each branch out of the multiple of branches is associated with a respective UL link. The network node 110 operates in the wireless communications network 100.

According to an example scenario, the network node 110 and its antenna system 112 are exposed to external interference e.g. from the neighbouring network node 111. The method provides improved robustness to the external interference.

The method may comprise one or more of the following actions which actions may be taken in any suitable order. These actions are performed for each respective UL link.

15 **Action 301**

The network node 110 may set a threshold value for an accepted link quality such as e.g. SNR of the UL link. This is to make sure that a new received symbol has good enough quality for the further processing.

The network node 110 may further set Done of Receiving, *doneOfReceiving*, of the 20 UL link to false. This is to initialize that the operation is not finished. **DoneOfReceiving** when used herein means a flag to determine whether the operation is complete or not.

Action 302

The network node 110, e.g. the corresponding RX link of the particular UL link of the 25 antenna system 112 in the network node 110, receives a number of subsequent symbols from an Antenna Interface (AI) transceiver of the antenna system 112. The symbols are Orthogonal Frequency Division Multiplex (OFDM) symbols. This is the baseline of IR and it enables IR in UL AC to improve robustness, efficiency and accuracy

30 **Action 303**

As mentioned above the network node 110 receives a number of subsequent symbols. These are received and looked on one by one. First a first symbol is received followed by one or more subsequent received symbols.

When a current received symbol is a first received symbol out of the number of 35 received symbols, the network node 110 may set *doneOfReceiving* to true. This is

performed to make sure that the received symbols have good enough signal quality to continue the further processing.

Action 304

5 When a current received symbol is not a first received symbol, it is one of the one or more subsequent received symbols. In that case, when the symbol is received after one or more previous received symbols of out of the received symbols, the network node 110 accumulates the current received symbol and the one or more previous received symbols. This is performed to increase the signal quality as more symbols being received.

10

Action 305

In some embodiments, the network node 110 performs blind estimation on the integer delay of the received symbols. An integer delay of the received symbols means the latency between the transmitted symbol and the received symbol on the sample
15 resolution. This blind estimation is performed to align the received symbol with respect to the transmitted symbol without any knowledge about the transmitted symbol.

Action 306

The network node 110 may measure the signal quality value of the received
20 symbols. The signal quality value will be used as the condition when performing the uplink antenna calibration.

In some of these embodiments, the measuring of the signal quality value of the received symbols is performed by using blind estimation with Cyclic Prefix (CP). **Blind estimation with CP** means utilizing the repetition of the CP samples within the OFDM
25 symbol, and is used to estimate the error between the transmitted symbol and the received symbol.

The signal quality value of the received symbols may be represented by any one out of: a Signal-to-Noise Ratio (SNR) value, and an Error Vector Magnitude (EVM) value, Mean Squared Error (MSE) value.

30

Action 307

When the signal quality value of the accumulated received symbols is smaller than a signal quality value of a symbol received previous of the current received symbol, the network node 110 discards the current received symbol. This is performed to make sure
35 that the new received symbol is beneficial to the signal quality.

Action 308

When the signal quality value of the accumulated received symbols is larger than a signal quality value of a symbol received previous of the current received symbol, the
 5 network node 110 sets the signal quality value for the particular branch and its associated UL link to be the accumulated signal quality value. This is performed to make sure the signal quality is increased monotonously.

Action 309

10 In some embodiments, when the accumulated signal quality value is above the threshold value, the network node 110 sets the *doneOfReceiving* to true. In this way, the received symbols have good enough signal quality to start the further processing.

15 The method described above will now be further explained and exemplified. In the examples herein, SNR is used as an example of signal quality; however the method may be applied to any signal quality to be measured.

Incremental redundancy based uplink antenna calibration

20 Incremental redundancy relates to the received a number of subsequent OFDM symbols, also referred to as calibration symbols, from the AI transceiver in Action 302.

Generally, an OFDM symbol may be expressed by **Figure 4** depicting how a Single OFDM Frame builds up.

The core OFDM symbol has a length of N_{fft} **samples**. To protect the symbol from
 25 Inter-Symbol-Interference (ISI), a few **redundant samples**, denoted by N_{cp} , are repeated at the beginning of the symbol. In the antenna calibration application environment, a highly self-correlated sequence, e.g. a Zadoff-Chu sequence, is inserted in the frequency domain at a specific sub-carrier position. This sequence has a very high correlation with itself, but very low correlation with the other sequence. Other sequence means any
 30 sequence that is not exactly the same as this one. This property, the high correlation with itself, but low correlation with other sequence, may be used to estimate the timing accuracy with a decent performance for blind estimation, the accuracy is sample based. The N_{cp} samples have a very high correlation with itself as well. If N_{cp} samples are estimated with the same number of samples, but N_{fft} samples after the start, and this
 35 estimation is moved along the sample-axis, then there can be seen a number of peaks,

which peaks indicate the start of the OFDM symbol, right at the start of the CP, but it may be removed to find the symbol start position. The accuracy in this case depends on the sampling rate when user applies the calculation.

5 For UL AC, to avoid a randomly continuously interference signal, the OFDM symbols will be transmitted in separate time. Each symbol has the same information. The receiver retrieves all the OFDM symbols, and will then accumulate the symbols to achieve a stronger signal quality such as in this example a stronger SNR. The received symbols will be added together, for this reason. If some symbols are destroyed by the interference,
10 it is still possible to achieve a better SNR, thanks to time domain diversity. As stated above, the UL AC may transmit the calibration symbol one by one to avoid interference and improve SNR performance. See **Figure 5** depicting an UL AC OFDM symbol transmission.

15 In the receiver side 10, the same signal will be received by all RX links in the network node 110. Since the channel condition of each uplink may be different, the received symbol may differ from branch to branch. Suppose having N_{symb} number of OFDM symbols, the time between each symbol may vary between antenna systems to antenna system. A good antenna system design will make sure each symbol is phase
20 aligned. In that case, the symbol may be accumulated to improve the signal quality, such as e.g. SNR. If the symbol on one or more receiving branches is interfered by interference, it will show a low SNR. To achieve a good result in the next step of the AC algorithm, the algorithm normally starts when all the AC symbols are accumulated. When there is no interference, however, a very few symbols are good enough to continue with
25 the further AC algorithm. On the other side, in a worst case, even when all the N_{symb} symbols are transmitted, there may still be seen a low SNR of the accumulated symbols on some of the branches. Accordingly, using constant value for N_{symb} is not a good solution for all the cases.

Therefore an IR method is provided, and blind CP synchronization and SNR
30 estimation are utilized to simplify the process. The blind CP SNR estimation method may be used to precisely estimate the SNR of the received symbol, and improve the UL AC by algorithm as following steps taken by the network node 110. **Figure 6a** and **Figure 6b**, depict a Flowchart of the algorithm in UL AC.

1. Set **601** the parameters: SNR threshold: SNR_{thr} , and set the flag of *doneOfReceiving* to be false for all the UL links, and start the UL AC calibration procedure.
2. For each uplink link:
 - 5 a. Check **602** flag of *doneOfReceiving* for this branch, if the flag is false:
 - i. If **603** this is the first received OFDM symbol, set the SNR value with the estimated value by CP SNR estimation;
 - Otherwise **604**, do the accumulation of the current symbol with the received symbols for this branch;
 - 10 ii. If the accumulated SNR smaller **605** than the previous SNR value, then discard this OFDM symbol;
 - Otherwise **606**, set the SNR value to the accumulated SNR value for this branch;
 - iii. Check **607** the accumulated SNR and compare it with the SNR_{thr} .
 1. If the accumulated SNR exceeds **608** the SNR_{thr} , mark the flag of *doneOfReceiving* for this branch is true, indicate the higher layer (they can turn off the UL of AC symbol receiving for example)
 - 15 2. Otherwise, continue with the next branch.
 3. When all the links are done, start the next step of AC algorithm **609**.
 - 20

CP Blind integer delay estimation

According to some embodiments herein, a simple SNR estimator is provided. A simple integer delay estimator may be used. Assume that , a series of complex sequence

25 of $x[k]$ are transmitted. When a core OFDM symbol, N_{fft} **samples**, is achieved, they will be converted from the frequency domain to time domain by an Inverse Fourier Transform operation (IFFT) operation. N_{fft} number of time domain samples will be produced, then the last redundant samples, denoted by N_{cp} **samples** will be copied at the beginning of the OFDM symbol. We denote the time domain signal as $s[k]$, the received signal $r[k]$ will

30 be affected by a complex, Additive White Gaussian Noise (AWGN) $n[k]$. Wherein k is the index of time domain samples. In the receiver side, normally the samples should collect ahead of the actual 1st OFDM symbols, which introduce a **timing error** τ' . Since the signal passes the analog domain, the timing error τ' would not be an exactly several received samples. However, with the blind estimation method with CP synchronization,

35 the integer part of the timing error may be estimated. The fractional part of the timing error

may be calculated in the frequency domain in the further processing, i.e. in the AC algorithm. The receiving procedure of the UL AC may be seen from **Figure 7**, depicting an UL AC receiving diagram.

5 The received signal $r[k]$ may be expressed as below:

$$r(k) = (s(k - \tau) + n(k - \tau))e^{j2\pi\epsilon k/N_{fft}} \quad \text{which } \tau' = \tau + \epsilon$$

The integer timing error τ can be estimated by the CP blind synchronization algorithm, the algorithm will be described below:

Assume that N_{tot} samples are received in the receiver side for $r[k]$, it may be
 10 determined by following factors: Number of OFDM symbols N_{symb} , core OFDM symbol size N_{fft} , CP size N_{cp} , extra capture samples N_{extra} , a formula to calculate N_{tot} : is as follows:

$$N_{tot} = N_{symb}(N_{fft} + N_{cp}) + N_{extra}$$

For the received signal $r[k]$, the index k is from 0 to $N_{tot} - 1$.

15 To calculate the correlation at position d , the below formula may be used:

$$0 \leq d < N_{tot} - N_{fft}$$

$$R(d) = \sum_{l=0}^{N_{cp}-1} r^*(d+l)r(d+l+N_{fft})$$

Multiple symbols N_{acc} may also be accumulated to reduce the peak uncertainty:

$$\tilde{R}(m) = \sum_{l=0}^{N_{acc}-1} R[m+l(N+N_{cp})]$$

20

Where $N_{acc} < N_{symb} - 1$, the peak samples in the $\tilde{R}$ indicate the start point of CP in each OFDM symbol. $\tilde{R}$ is the accumulation of R in multiple symbols and R is the correlation of CP samples and end part of OFDM symbol. If the index of the peaks is denoted by m' , the frequency error may be continued to be calculates by below formula:

25

$$f_{err} = \angle \tilde{R}(m') / (2 * \pi * N_{fft})$$

CP Blind SNR estimation

To avoid high computation complexity, blindly estimating the SNR with good
 30 achievable accuracy is important for embodiments of the algorithm to make proper decision. CP information may be used to estimate the SNR as well. Back to Figure 4, in

the OFDM symbol generation phase, the CP samples are copied from the last N_{cp} samples in the OFDM symbol, denoted as:

$$s[k] = s[k + N_{fft}]$$

Where k is from 0 to $N_{cp} - 1$ for each OFDM symbol. In the received signal $r[k]$, it is assumed that the channel is linear, mainly caused by filtering in AAS, and affected by AWGN $n[k]$. If it is possible to accurately estimate the start of the CP position in each symbol, then the SNR for this symbol may be estimated by a simple blind CP method without knowledge of other information.

See **Figure 8** depicting a received signal model. After the synchronization, the received signal r_{cp} is the transmitted signal s_{cp} plus a noise signal $n_1[k]$, and the received signal $r_{cp'}$ is the transmitted signal s_{cp} plus a noise signal $n_2[k]$. Assuming the noise signals $n_1[k]$ and $n_2[k]$ are unrelated, and with a power of σ_n^2 , there may be:

$$r_{cp}[k] = s_{cp}[k] + n_1[k]$$

$$r_{cp'}[k] = s_{cp}[k + N_{fft}] + n_2[k]$$

Where k is from 0 to $N_{cp} - 1$. In the assumption, since n_1 and n_2 are unrelated, the difference $n_1 - n_2$ has a power of $2\sigma_n^2$, and the sum $n_1 + n_2$ also has a power of $2\sigma_n^2$. Since $s_{cp}[k]$ is a copy of $s_{cp}[k + N_{fft}]$, and the received signal is perfectly aligned, the sum of r_{cp} and $r_{cp'}$ ($r_{cp} + r_{cp'}$) will have a power of: $4\sigma_s^2 + 2\sigma_n^2$, and difference of r_{cp} and $r_{cp'}$ ($r_{cp} - r_{cp'}$) will have a power of $2\sigma_n^2$, which means:

$$\frac{\sum_{k=0}^{N_{cp}-1} (r_{cp}[k] + r_{cp'}[k]) (r_{cp}^*[k] + r_{cp'}^*[k])}{\sum_{k=0}^{N_{cp}-1} (r_{cp}[k] - r_{cp'}[k]) (r_{cp}^*[k] - r_{cp'}^*[k])} = \frac{4\sigma_s^2 + 2\sigma_n^2}{2\sigma_n^2} = 2 \frac{\sigma_s^2}{\sigma_n^2} + 1 = 2SNR_{symb} + 1$$

From the formula above, the SNR_{symb} may simply be calculated. Furthermore, multiple OFDM symbols may be accumulated to improve the SNR result. Here different idea SNR values are simulated with respect to different CP length in case of the blind estimation algorithm, the configuration in **Figure 9** is:

- OFDM symbol length: 256
- Number of used carriers: 159
- Noise added with idea SNR from 0 to 32
- Number of CP length is simulated for several selections

Figure 9 depicts Blind SNR estimation performance simulation, wherein the x axis is representing SNR in dB and the y axis is representing Estimated SNR Error in dB. In Figure 9, the **line marked with circles** represents CP = 32, the **line marked with**

rhombs represents CP = 64, the **line marked with squares** represents CP = 80, and the **line marked with triangles** represents CP = 112.

From the result, it is shown that the performance gets better when the CP length is increased. This is as expected, because more samples may be used for the estimation. However, longer CP length will lead to lower efficiency. The estimation behaves quite stable versus the SNR value. Even when the SNR is very low, the SNR value may still be estimated with a very good approximation, which helps to further improve the system by our invention idea.

10

To perform the method actions above the network node 110 is configured to perform an uplink antenna calibration of an antenna system 112 of the network node 110, and may comprise the arrangement depicted in **Figure 10a** and **10b**. As mentioned above, the antenna system 112 is adapted to comprise multiple branches, wherein each branch out of the multiple of branches is adapted to be associated with a respective UL link. The network node 110 is operable in the wireless communications network 100.

The network node 110 may comprise **an input and output interface 1100** configured to communicate e.g. with the UE 120. The input and output interface 1100 may comprise a wireless receiver (not shown) and a wireless transmitter (not shown).

The network node 110 is configured to for each respective UL link, e.g. by means of a **receiving unit 1110** in the network node 110, receive a number of subsequent symbols from an AI transceiver of the antenna system 112, which symbols are adapted to be OFDM symbols.

The network node 110 is configured to for each respective UL link, e.g. by means of a **accumulating unit 1120** in the network node 110, when a current received symbol is received after one or more previous received symbols of out of the received symbols, accumulate the current received symbol and the one or more previous received symbols.

The network node 110 is configured to for each respective UL link, e.g. by means of a **discarding unit 1130** in the network node 110, when the signal quality value of the

accumulated received symbols is smaller than a signal quality value of a symbol received previous of the current received symbol, discard the current received symbol.

The network node 110 is configured to for each respective UL link, e.g. by means
5 of a **setting unit 1140** in the network node 110, when the signal quality value of the accumulated received symbols is larger than a signal quality value of a symbol received previous of the current received symbol, set the signal quality value for the particular branch and its associated UL link to be the accumulated signal quality value.

10 The network node 110 may further be configured to for each respective UL link, e.g. by means of an **estimating unit 1150** in the network node 110, perform blind estimation of the integer delay of the received symbols.

The network node 110 may further be configured to for each respective UL link,
15 e.g. by means of a **measuring unit 1160** in the network node 110, measure the signal quality value of the received symbols.

The network node 110 may further be configured to for each respective UL link, e.g. by means of the **measuring unit 1160** in the network node 110, measure the signal quality value of the received symbols by using blind estimation with CP.

20 The signal quality value of the received symbols may be adapted to be represented by any one out of: an SNR, value, an EVM value, and an MSE value.

The network node 110 may further be configured to for each respective UL link, e.g. by means of the **setting unit 1140** in the network node 110, set any one or more out
25 of: - A threshold value for an accepted link quality SNR of the UL link, and - Done of Receiving, doneOfReceiving, of the UL link to false.

The network node 110 may further be configured to for each respective UL link, e.g. by means of the **setting unit 1140** in the network node 110, when a current received symbol is a first received symbol out of the number of received symbols, set
30 doneOfReceiving to true.

The network node 110 may further be configured to for each respective UL link, e.g. by means of the **setting unit 1140** in the network node 110, when the accumulated signal quality value is above the threshold value, set the doneOfReceiving to true.

The embodiments herein may be implemented through a respective processor or one or more processors, such as the **processor 1170** of a processing circuitry in the network node 110, depicted in Figure 10a together with computer program code for performing the functions and actions of the embodiments herein. The program code
5 mentioned above may also be provided as a computer program product, for instance in the form of a data carrier carrying computer program code for performing the embodiments herein when being loaded into the network node 110. One such carrier may be in the form of a CD ROM disc. It is however feasible with other data carriers such as a memory stick. The computer program code may furthermore be provided as pure program
10 code on a server and downloaded to the network node 110.

The network node 110 may further comprise a **memory 1180** comprising one or more memory units. The memory comprises instructions executable by the processor in the network node 110. The memory 1180 is arranged to be used to store e.g. signal
15 quality values, information, data, configurations, and applications to perform the methods herein when being executed in the network node 110.

In some embodiments, a **computer program 1190** comprises instructions, which when executed by the at least one processor, cause the at least one processor of the
20 network node 110, to perform the actions above.

In some embodiments, a **carrier 1195** comprises the computer program 1190, wherein the carrier is one of an electronic signal, an optical signal, an electromagnetic signal, a magnetic signal, an electric signal, a radio signal, a microwave signal, or a
25 computer-readable storage medium.

Those skilled in the art will also appreciate that the units in the network node 110 described above may refer to a combination of analog and digital circuits, and/or one or more processors configured with software and/or firmware, e.g. stored in the network
30 node 110, that when executed by the respective one or more processors such as the processors described above. One or more of these processors, as well as the other digital hardware, may be included in a single Application-Specific Integrated Circuitry (ASIC), or several processors and various digital hardware may be distributed among several separate components, whether individually packaged or assembled into a system-on-a-
35 chip (SoC).

With reference to **Figure 11**, in accordance with an embodiment, a communication system includes a telecommunication network 3210, such as a 3GPP-type cellular network, which comprises an access network 3211, such as a radio access network, and a core network 3214. The access network 3211 comprises a plurality of base stations 3212a, 3212b, 3212c, such as the network node 110, AP STAs NBs, eNBs, gNBs or other types of wireless access points, each defining a corresponding coverage area 3213a, 3213b, 3213c. Each base station 3212a, 3212b, 3212c is connectable to the core network 3214 over a wired or wireless connection 3215. A first user equipment (UE) such as the UE 120, a Non-AP STA 3291 located in coverage area 3213c is configured to wirelessly connect to, or be paged by, the corresponding base station 3212c. A second UE 3292 such as a Non-AP STA in coverage area 3213a is wirelessly connectable to the corresponding base station 3212a. While a plurality of UEs 3291, 3292 are illustrated in this example, the disclosed embodiments are equally applicable to a situation where a sole UE is in the coverage area or where a sole UE is connecting to the corresponding base station 3212.

The telecommunication network 3210 is itself connected to a host computer 3230, which may be embodied in the hardware and/or software of a standalone server, a cloud-implemented server, a distributed server or as processing resources in a server farm. The host computer 3230 may be under the ownership or control of a service provider, or may be operated by the service provider or on behalf of the service provider. The connections 3221, 3222 between the telecommunication network 3210 and the host computer 3230 may extend directly from the core network 3214 to the host computer 3230 or may go via an optional intermediate network 3220. The intermediate network 3220 may be one of, or a combination of more than one of, a public, private or hosted network; the intermediate network 3220, if any, may be a backbone network or the Internet; in particular, the intermediate network 3220 may comprise two or more sub-networks (not shown).

The communication system of Figure 11 as a whole enables connectivity between one of the connected UEs 3291, 3292 and the host computer 3230. The connectivity may be described as an over-the-top (OTT) connection 3250. The host computer 3230 and the connected UEs 3291, 3292 are configured to communicate data and/or signaling via the OTT connection 3250, using the access network 3211, the core network 3214, any intermediate network 3220 and possible further infrastructure (not

shown) as intermediaries. The OTT connection 3250 may be transparent in the sense that the participating communication devices through which the OTT connection 3250 passes are unaware of routing of uplink and downlink communications. For example, a base station 3212 may not or need not be informed about the past routing of an incoming
5 downlink communication with data originating from a host computer 3230 to be forwarded (e.g., handed over) to a connected UE 3291. Similarly, the base station 3212 need not be aware of the future routing of an outgoing uplink communication originating from the UE 3291 towards the host computer 3230.

Example implementations, in accordance with an embodiment, of the UE, base station
10 and host computer discussed in the preceding paragraphs will now be described with reference to Figure 12. In a communication system 3300, a host computer 3310 comprises hardware 3315 including a communication interface 3316 configured to set up and maintain a wired or wireless connection with an interface of a different communication device of the communication system 3300. The host computer 3310 further comprises
15 processing circuitry 3318, which may have storage and/or processing capabilities. In particular, the processing circuitry 3318 may comprise one or more programmable processors, application-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. The host computer 3310 further comprises software 3311, which is stored in or accessible by the host
20 computer 3310 and executable by the processing circuitry 3318. The software 3311 includes a host application 3312. The host application 3312 may be operable to provide a service to a remote user, such as a UE 3330 connecting via an OTT connection 3350 terminating at the UE 3330 and the host computer 3310. In providing the service to the remote user, the host application 3312 may provide user data which is transmitted using
25 the OTT connection 3350.

The communication system 3300 further includes a base station 3320 provided in a telecommunication system and comprising hardware 3325 enabling it to communicate with the host computer 3310 and with the UE 3330. The hardware 3325 may include a communication interface 3326 for setting up and maintaining a wired or wireless
30 connection with an interface of a different communication device of the communication system 3300, as well as a radio interface 3327 for setting up and maintaining at least a wireless connection 3370 with a UE 3330 located in a coverage area (not shown in Figure 12) served by the base station 3320. The communication interface 3326 may be configured to facilitate a connection 3360 to the host computer 3310. The connection
35 3360 may be direct or it may pass through a core network (not shown in Figure 12) of the

telecommunication system and/or through one or more intermediate networks outside the telecommunication system. In the embodiment shown, the hardware 3325 of the base station 3320 further includes processing circuitry 3328, which may comprise one or more programmable processors, application-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. The base station 3320 further has software 3321 stored internally or accessible via an external connection.

The communication system 3300 further includes the UE 3330 already referred to. Its hardware 3335 may include a radio interface 3337 configured to set up and maintain a wireless connection 3370 with a base station serving a coverage area in which the UE 3330 is currently located. The hardware 3335 of the UE 3330 further includes processing circuitry 3338, which may comprise one or more programmable processors, application-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. The UE 3330 further comprises software 3331, which is stored in or accessible by the UE 3330 and executable by the processing circuitry 3338. The software 3331 includes a client application 3332. The client application 3332 may be operable to provide a service to a human or non-human user via the UE 3330, with the support of the host computer 3310. In the host computer 3310, an executing host application 3312 may communicate with the executing client application 3332 via the OTT connection 3350 terminating at the UE 3330 and the host computer 3310. In providing the service to the user, the client application 3332 may receive request data from the host application 3312 and provide user data in response to the request data. The OTT connection 3350 may transfer both the request data and the user data. The client application 3332 may interact with the user to generate the user data that it provides. It is noted that the host computer 3310, base station 3320 and UE 3330 illustrated in Figure 12 may be identical to the host computer 3230, one of the base stations 3212a, 3212b, 3212c and one of the UEs 3291, 3292 of Figure 11, respectively. This is to say, the inner workings of these entities may be as shown in Figure 12 and independently, the surrounding network topology may be that of Figure 11.

In Figure 12, the OTT connection 3350 has been drawn abstractly to illustrate the communication between the host computer 3310 and the use equipment 3330 via the base station 3320, without explicit reference to any intermediary devices and the precise routing of messages via these devices. Network infrastructure may determine the routing, which it may be configured to hide from the UE 3330 or from the service provider operating the host computer 3310, or both. While the OTT connection 3350 is

active, the network infrastructure may further take decisions by which it dynamically changes the routing (e.g., on the basis of load balancing consideration or reconfiguration of the network).

The wireless connection 3370 between the UE 3330 and the base station 3320 is in accordance with the teachings of the embodiments described throughout this disclosure. [If the radio-related invention has not yet been formulated at the time of drafting a provisional application, the expression “embodiments described throughout this disclosure” is meant to refer to the radio-related embodiments disclosed elsewhere in the application.] One or more of the various embodiments improve the performance of OTT services provided to the UE 3330 using the OTT connection 3350, in which the wireless connection 3370 forms the last segment. More precisely, the teachings of these embodiments may improve the [select the applicable **RAN** effect: data rate, latency, power consumption] and thereby provide benefits such as [select the applicable corresponding effect on the **OTT service**: reduced user waiting time, relaxed restriction on file size, better responsiveness, extended battery lifetime].

A measurement procedure may be provided for the purpose of monitoring data rate, latency and other factors on which the one or more embodiments improve. There may further be an optional network functionality for reconfiguring the OTT connection 3350 between the host computer 3310 and UE 3330, in response to variations in the measurement results. The measurement procedure and/or the network functionality for reconfiguring the OTT connection 3350 may be implemented in the software 3311 of the host computer 3310 or in the software 3331 of the UE 3330, or both. In embodiments, sensors (not shown) may be deployed in or in association with communication devices through which the OTT connection 3350 passes; the sensors may participate in the measurement procedure by supplying values of the monitored quantities exemplified above, or supplying values of other physical quantities from which software 3311, 3331 may compute or estimate the monitored quantities. The reconfiguring of the OTT connection 3350 may include message format, retransmission settings, preferred routing etc.; the reconfiguring need not affect the base station 3320, and it may be unknown or imperceptible to the base station 3320. Such procedures and functionalities may be known and practiced in the art. In certain embodiments, measurements may involve proprietary UE signaling facilitating the host computer’s 3310 measurements of throughput, propagation times, latency and the like. The measurements may be implemented in that the software 3311, 3331 causes messages to be transmitted, in

particular empty or 'dummy' messages, using the OTT connection 3350 while it monitors propagation times, errors etc.

[Figures 34 and 35 and the corresponding text are about a downstream aspect of the radio-related invention, while figures 36 and 37 and the corresponding text discuss an upstream aspect. If only one aspect is applicable for an invention, then, because the text and drawings are self-contained for each aspect, the text and drawings for the other aspect may be omitted without disadvantage.]

FIGURE 13 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station such as an AP STA, and a UE such as a Non-AP STA which may be those described with reference to Figure 11 and Figure 12. For simplicity of the present disclosure, only drawing references to Figure 13 will be included in this section. In a first step 3410 of the method, the host computer provides user data. In an optional substep 3411 of the first step 3410, the host computer provides the user data by executing a host application. In a second step 3420, the host computer initiates a transmission carrying the user data to the UE. In an optional third step 3430, the base station transmits to the UE the user data which was carried in the transmission that the host computer initiated, in accordance with the teachings of the embodiments described throughout this disclosure. In an optional fourth step 3440, the UE executes a client application associated with the host application executed by the host computer.

FIGURE 14 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station such as an AP STA, and a UE such as a Non-AP STA which may be those described with reference to Figure 11 and Figure 12. For simplicity of the present disclosure, only drawing references to Figure 14 will be included in this section. In a first step 3510 of the method, the host computer provides user data. In an optional substep (not shown) the host computer provides the user data by executing a host application. In a second step 3520, the host computer initiates a transmission carrying the user data to the UE. The transmission may pass via the base station, in accordance with the teachings of the embodiments described throughout this disclosure. In an optional third step 3530, the UE receives the user data carried in the transmission.

FIGURE 15 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station such as an AP STA, and a UE such as a Non-AP STA which may be those described with reference to Figure 11 and Figure 12. For

simplicity of the present disclosure, only drawing references to Figure 15 will be included in this section. In an optional first step 3610 of the method, the UE receives input data provided by the host computer. Additionally or alternatively, in an optional second step 3620, the UE provides user data. In an optional substep 3621 of the second step 3620, 5 the UE provides the user data by executing a client application. In a further optional substep 3611 of the first step 3610, the UE executes a client application which provides the user data in reaction to the received input data provided by the host computer. In providing the user data, the executed client application may further consider user input received from the user. Regardless of the specific manner in which the user data was 10 provided, the UE initiates, in an optional third substep 3630, transmission of the user data to the host computer. In a fourth step 3640 of the method, the host computer receives the user data transmitted from the UE, in accordance with the teachings of the embodiments described throughout this disclosure.

FIGURE 16 is a flowchart illustrating a method implemented in a 15 communication system, in accordance with one embodiment. The communication system includes a host computer, a base station such as an AP STA, and a UE such as a Non-AP STA which may be those described with reference to Figure 11 and Figure 12. For simplicity of the present disclosure, only drawing references to Figure 16 will be included in this section. In an optional first step 3710 of the method, in accordance with the 20 teachings of the embodiments described throughout this disclosure, the base station receives user data from the UE. In an optional second step 3720, the base station initiates transmission of the received user data to the host computer. In a third step 3730, the host computer receives the user data carried in the transmission initiated by the base station.

25

When using the word "comprise" or "comprising" it shall be interpreted as non-limiting, i.e. meaning "consist at least of".

The embodiments herein are not limited to the above described preferred 30 embodiments. Various alternatives, modifications and equivalents may be used.

	Abbreviation	Explanation
	AAS	Active Antenna System
35	AC	Antenna Calibration

	IR	Incremental Redundancy
	UL	Uplink
	DL	Downlink
	CP	Cyclic prefix
5	GP	Guard period
	AI	Antenna interface
	SNR	Signal-to-noise ratio
	OFDM	Orthogonal frequency domain multiplexing
	MIMO	Multiple-input multiple-output
10	ISI	Inter-symbol interference

CLAIMS

1. A method performed by a network node (110) for performing an uplink antenna calibration of an antenna system (112) of the network node (110), which antenna system (112) comprises multiple branches, wherein each branch out of the multiple of branches is associated with a respective Uplink, UL, link, and which network node (110) is operating in a wireless communications network (100), the method comprising for each respective UL link:
 - receiving* (302) a number of subsequent symbols from an Antenna Interface, AI, transceiver of the antenna system (112), which symbols are Orthogonal Frequency Division Multiplex, OFDM, symbols,
 - when a current received symbol is received after one or more previous received symbols of out of the received symbols, *accumulating* (304) the current received symbol and the one or more previous received symbols,
 - when the signal quality value of the accumulated received symbols is smaller than a signal quality value of a symbol received previous of the current received symbol, *discarding* (307) the current received symbol,
 - when the signal quality value of the accumulated received symbols is larger than a signal quality value of a symbol received previous of the current received symbol, *setting* (308) the signal quality value for the particular branch and its associated UL link to be the accumulated signal quality value.
2. The method according to claim 1, further comprising for each respective UL link:
 - performing* (305) blind estimation of the integer delay of the received symbols.
3. The method according to any of the claims 1-2, further comprising for each respective UL link:
 - measuring* (306) the signal quality value of the received symbols.
4. The method according to claim 3, wherein *measuring* (306) the signal quality value of the received symbols is performed by using blind estimation with Cyclic Prefix, CP.
5. The method according to any of the claims 1-4, wherein the signal quality value of the received symbols are represented by any one out of: a Signal-to-Noise Ratio,

SNR, value, an Error Vector Magnitude, EVM, value, and a Mean Squared Error, MSE value.

6. The method according any of the claims 1-5, further comprising
5 *setting* (301) any one or more out of:
 - a threshold value for an accepted link quality (SNR) of the UL link, and
 - Done of Receiving, *doneOfReceiving*, of the UL link to false.
7. The method according to claim 6, further comprising for each respective UL link:
10 when a current received symbol is a first received symbol out of the number of received symbols, *setting* (303) *doneOfReceiving* to true.
8. The method according to any of the claims 6-7, further comprising for each respective UL link:
15 when the accumulated signal quality value is above the threshold value, *setting* (309) the *doneOfReceiving* to true.
9. A computer program (1190) comprising instructions, which when executed by a processor (1170), causes the processor (1170) to perform actions according to any
20 of the claims 1-8.
10. A carrier (1195) comprising the computer program (1190) of claim 9, wherein the carrier (1195) is one of an electronic signal, an optical signal, an electromagnetic signal, a magnetic signal, an electric signal, a radio signal, a microwave signal, or a
25 computer-readable storage medium.
11. A network node (110) configured to perform an uplink antenna calibration of an antenna system (112) of the network node (110), which antenna system (112) is adapted to comprise multiple branches, wherein each branch out of the multiple of
30 branches is adapted to be associated with a respective Uplink, UL, link, and which network node (110) is operable in a wireless communications network (100), the network node (110) being further configured to, for each respective UL link:
 - receive* a number of subsequent symbols from an Antenna Interface, AI, transceiver of the antenna system (112), which symbols are adapted to be
35 Orthogonal Frequency Division Multiplex, OFDM, symbols,

when a current received symbol is received after one or more previous received symbols of out of the received symbols, *accumulate* the current received symbol and the one or more previous received symbols,

5 when the signal quality value of the accumulated received symbols is smaller than a signal quality value of a symbol received previous of the current received symbol, *discard* the current received symbol,

10 when the signal quality value of the accumulated received symbols is larger than a signal quality value of a symbol received previous of the current received symbol, *set* the signal quality value for the particular branch and its associated UL link to be the accumulated signal quality value.

12. The network node (110) according to claim 11, further being configured to, for each respective UL link:

15 *perform* blind estimation of the integer delay of the received symbols.

13. The network node (110) according to any of the claims 11-12, further being configured to, for each respective UL link:

measure the signal quality value of the received symbols.

20 14. The network node (110) according to claim 13, further being configured to *measure* the signal quality value of the received symbols by using blind estimation with Cyclic Prefix, CP.

25 15. The network node (110) according to any of the claims 11-14, wherein the signal quality value of the received symbols are adapted to be represented by any one out of: a Signal-to-Noise Ratio, SNR, value, an Error Vector Magnitude, EVM, value, and a Mean Squared Error, MSE value.

30 16. The network node (110) according any of the claims 11-15, further being configured to for each respective UL link *set* any one or more out of:

- a threshold value for an accepted link quality (SNR) of the UL link, and
- Done of Receiving, *doneOfReceiving*, of the UL link to false,

35 17. The network node (110) according to claim 16, further being configured to, for each respective UL link:

when a current received symbol is a first received symbol out of the number of received symbols, set *doneOfReceiving* to true.

18. The network node (110) according to any of the claims 16-17, further being
5 configured to, for each respective UL link:
when the accumulated signal quality value is above the threshold value, set the *doneOfReceiving* to true.

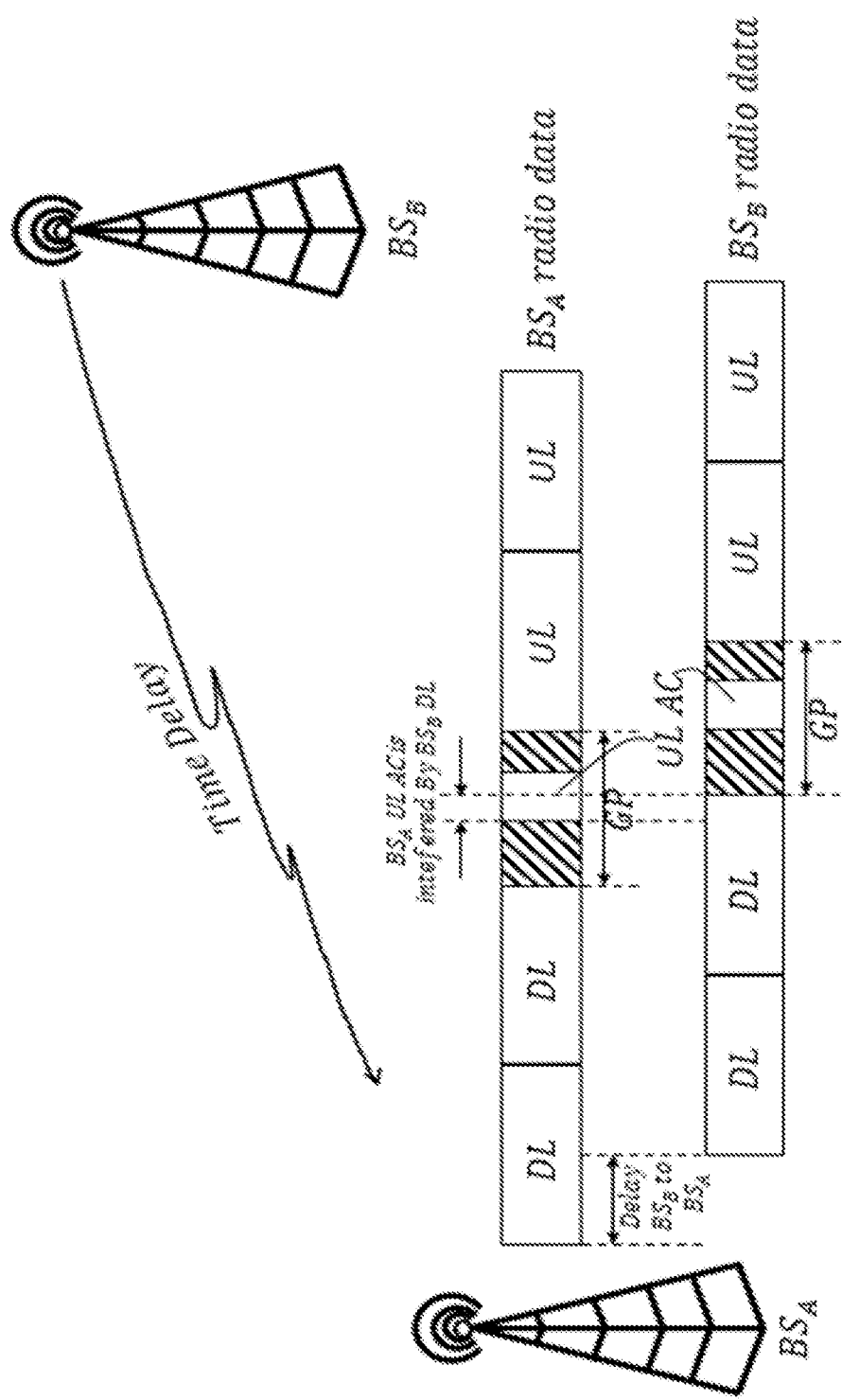


Fig. 1

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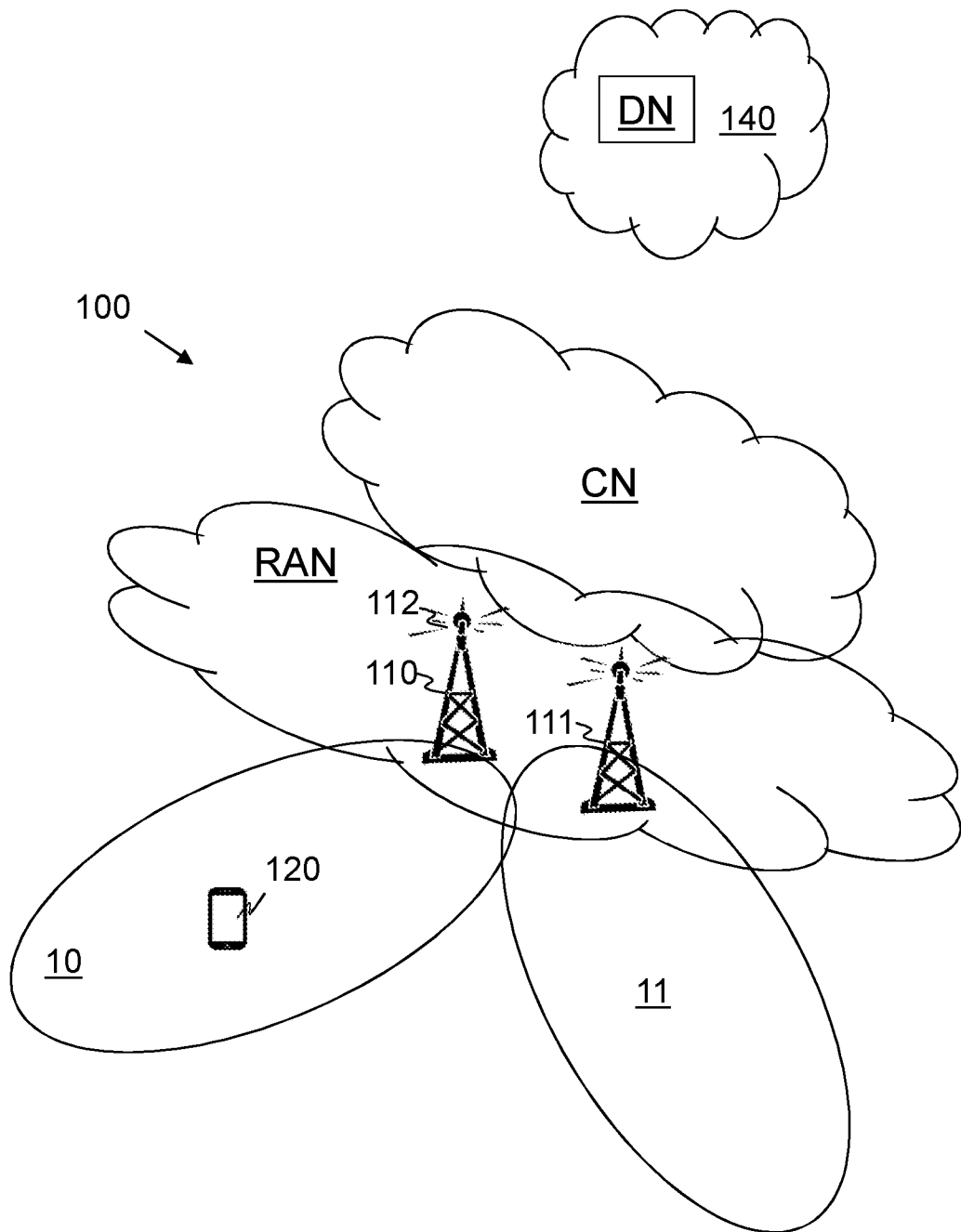


Fig. 2

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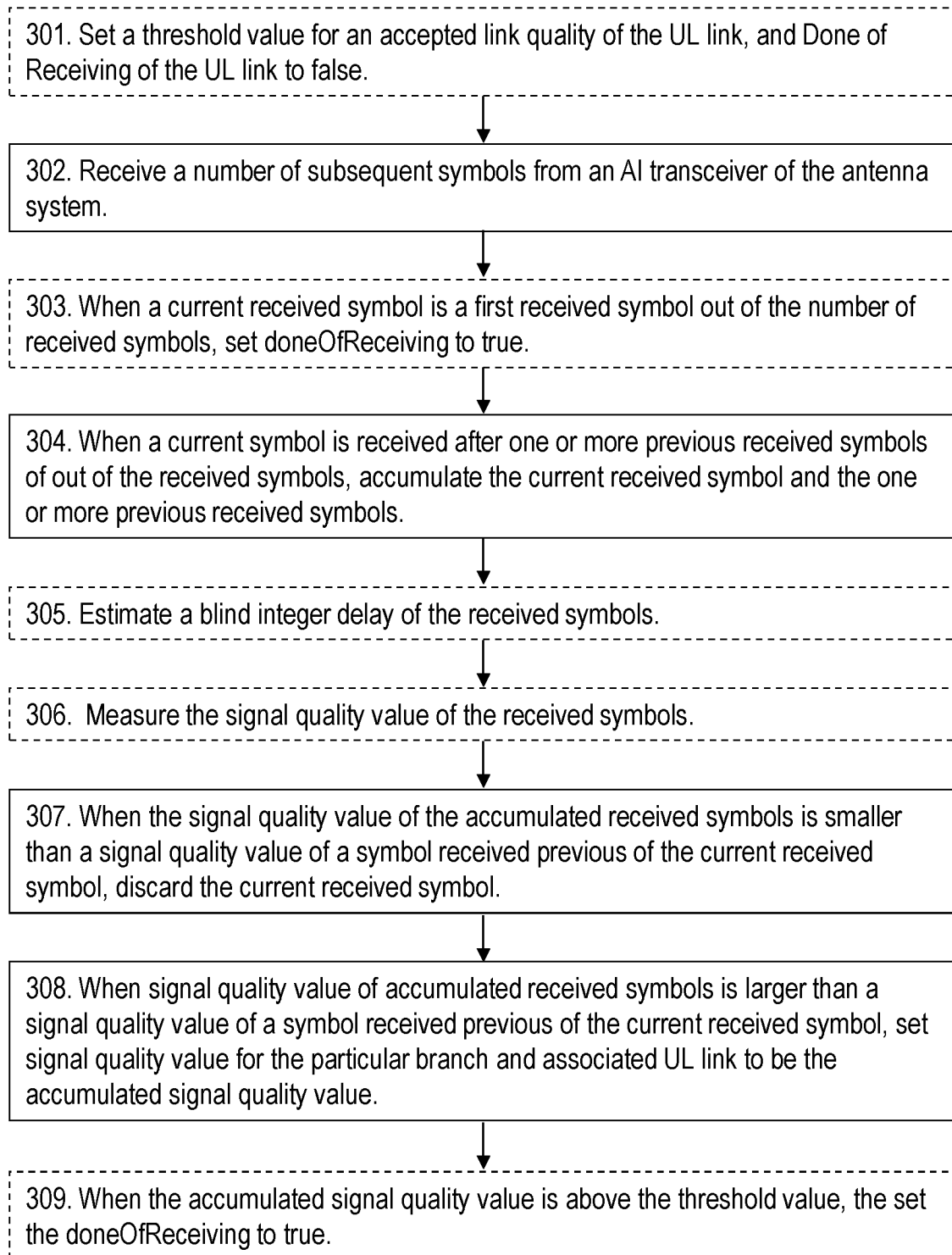


Fig. 3 Method in network node 110

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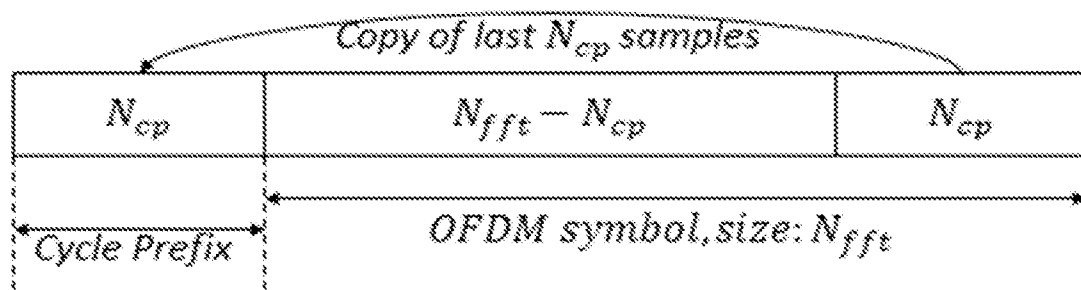


Fig. 4

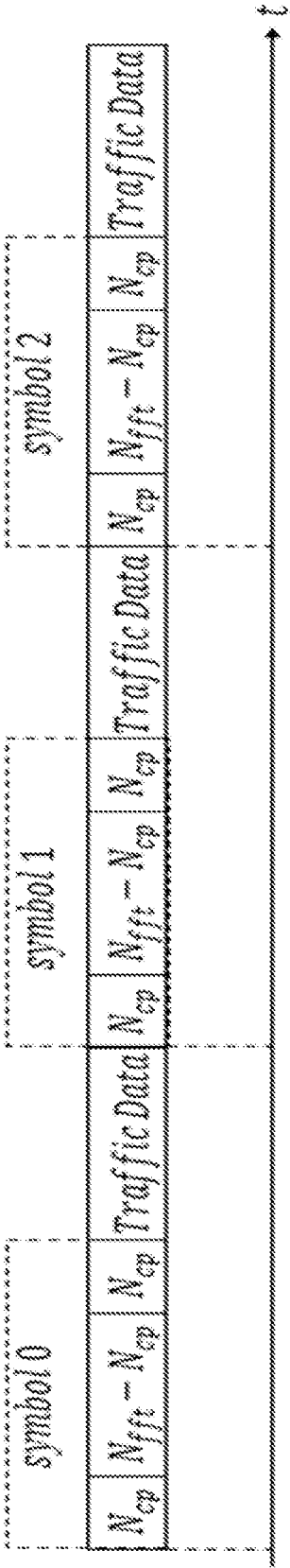


Fig. 5

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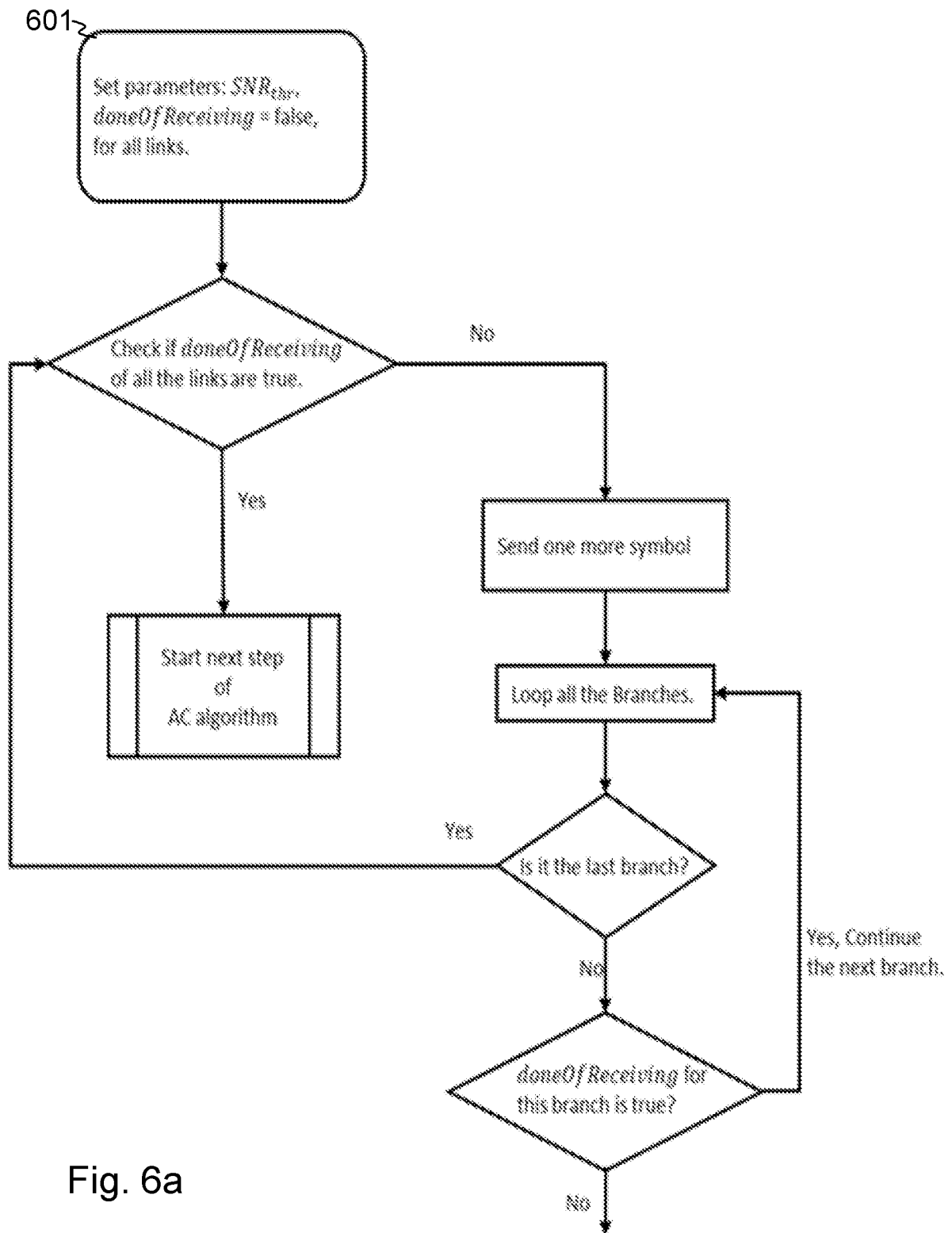


Fig. 6a

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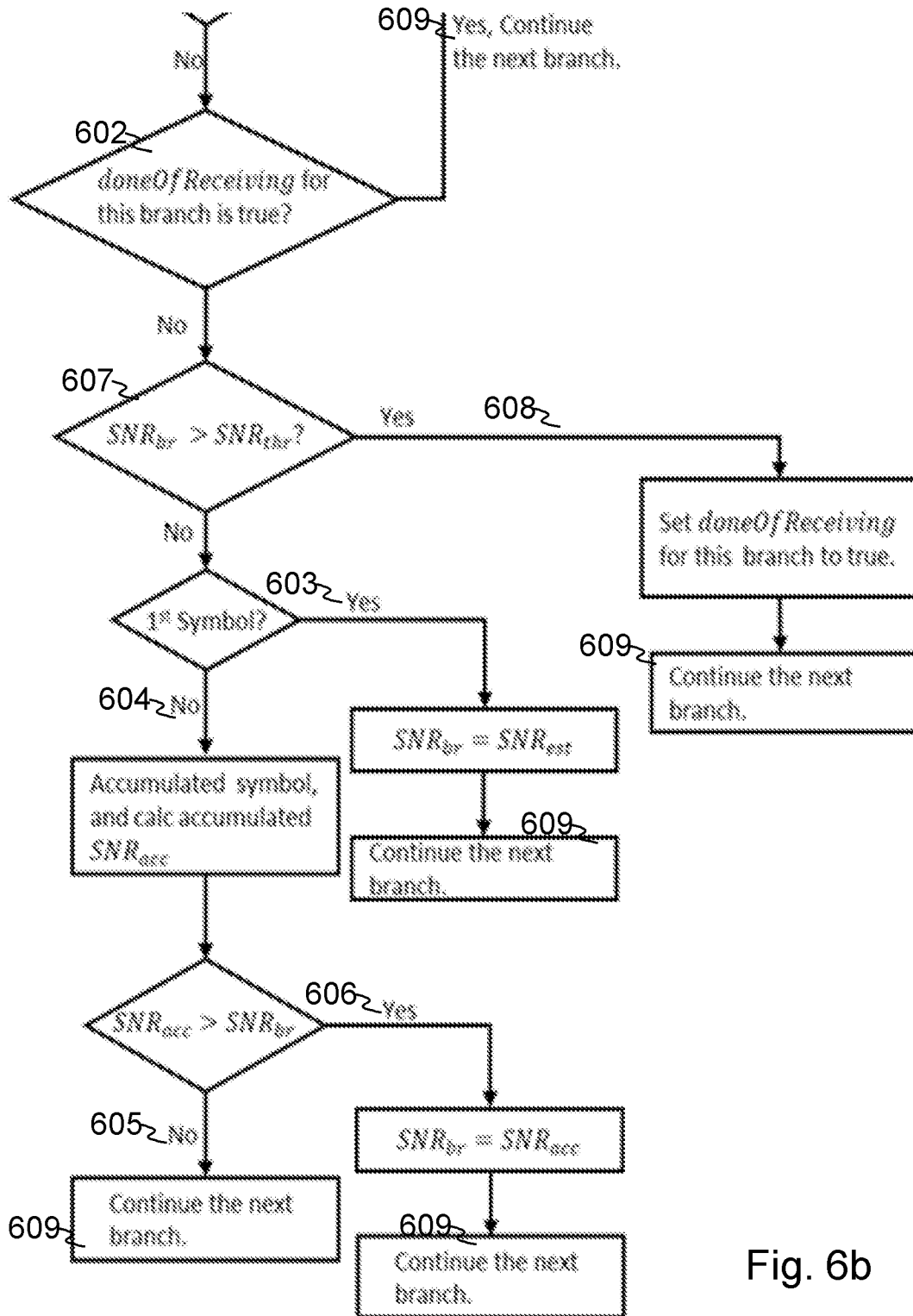


Fig. 6b

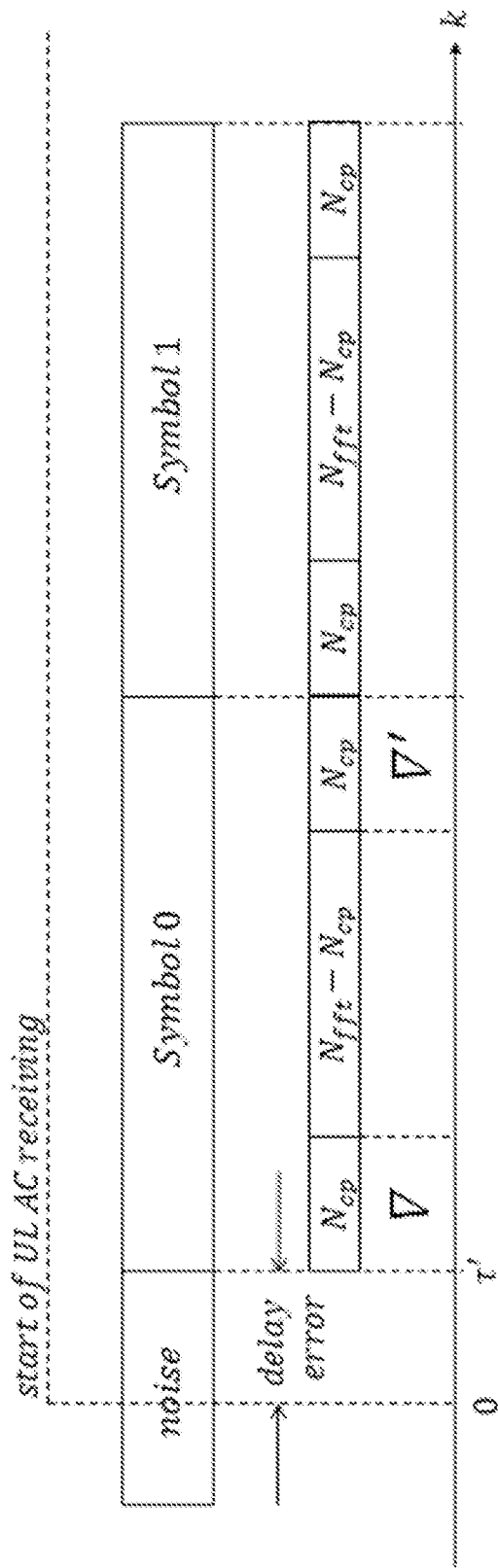


Fig. 7

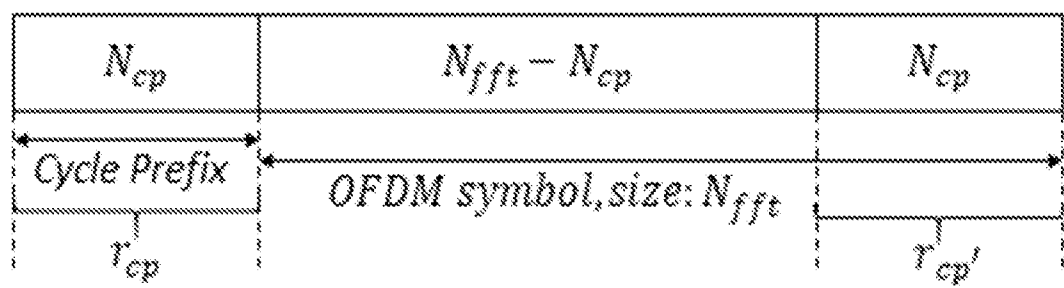


Fig. 8

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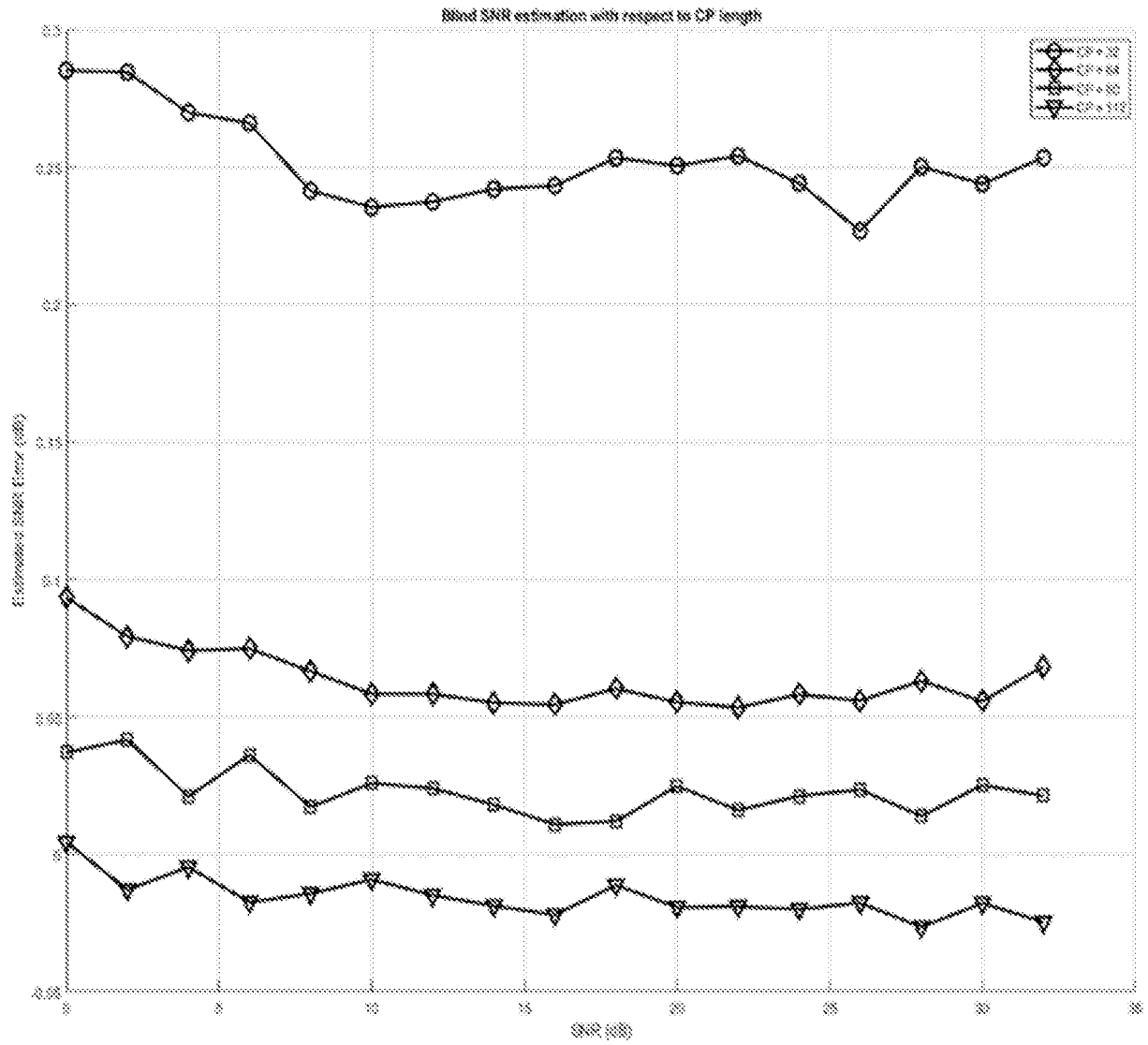


Fig. 9

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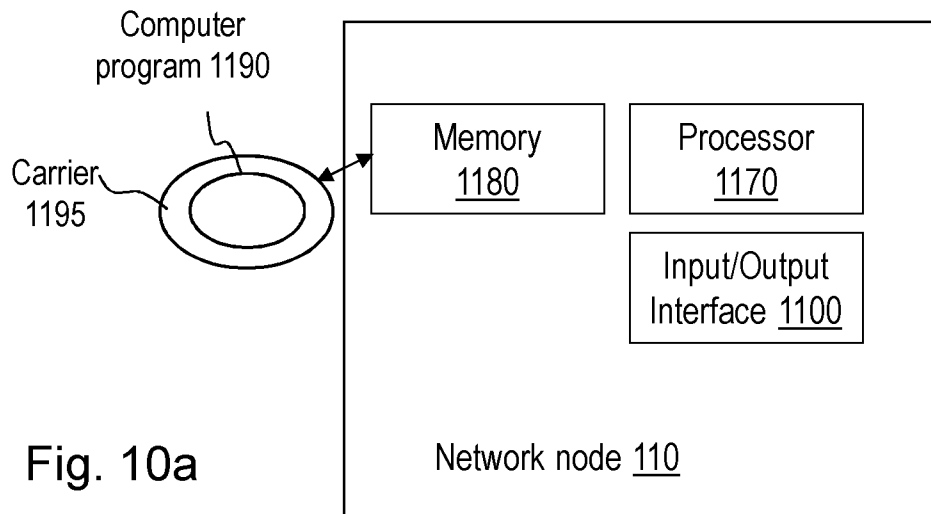


Fig. 10a

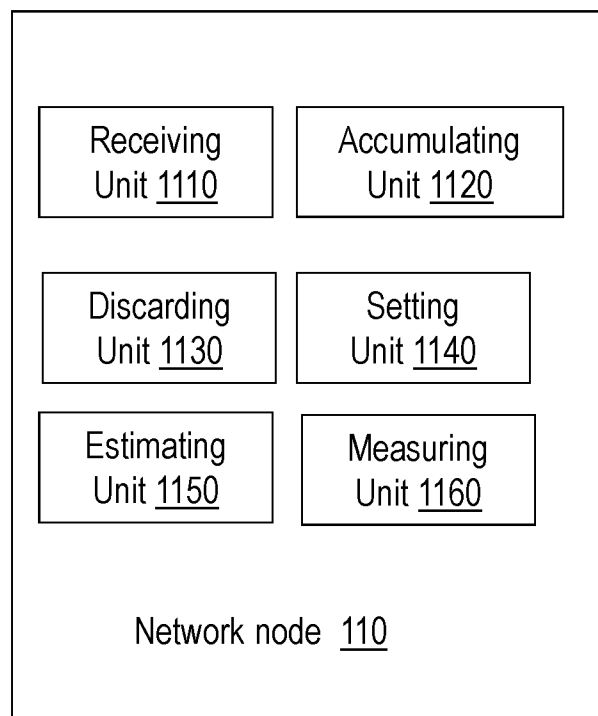


Fig. 10b

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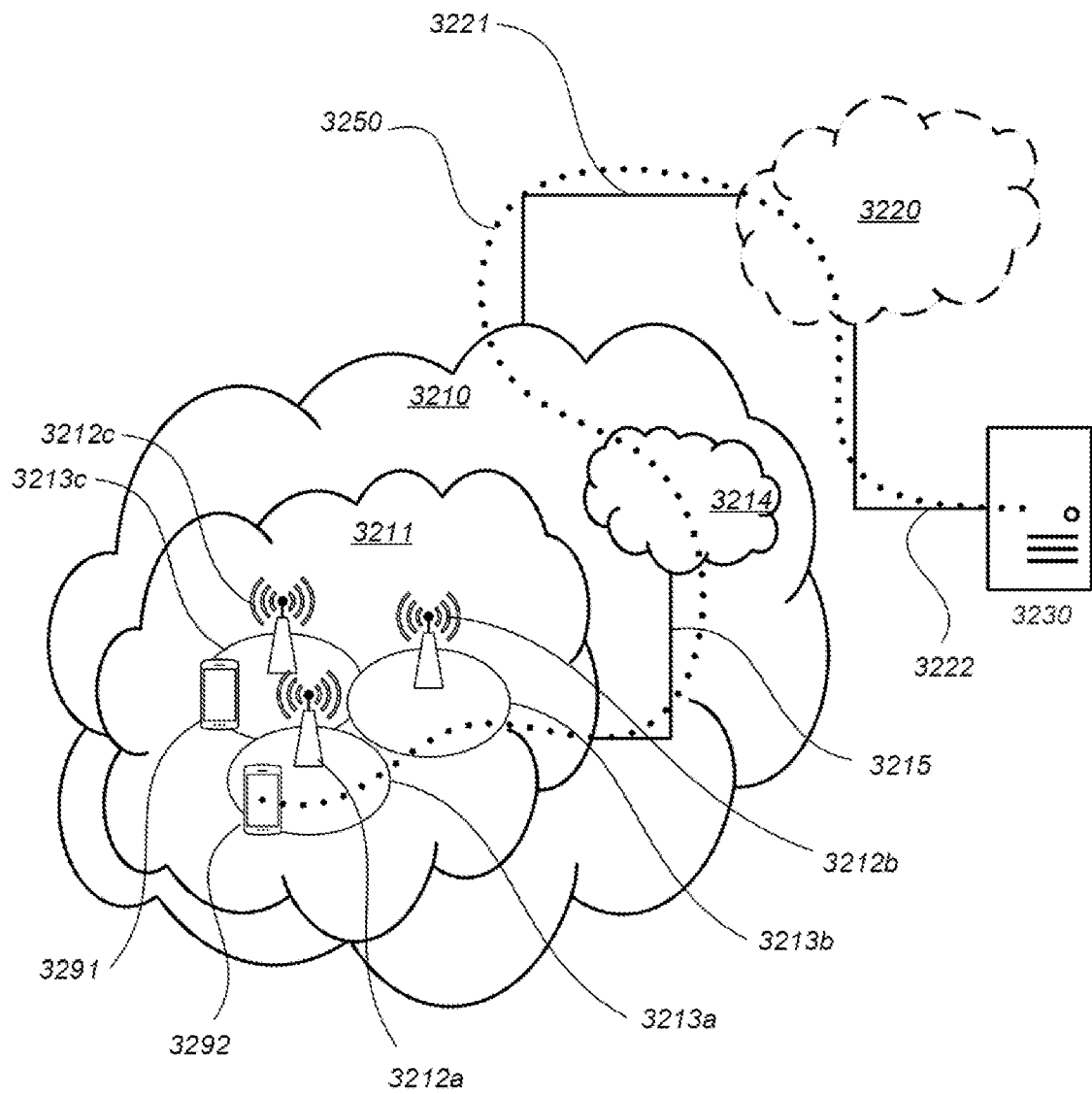


Fig. 11

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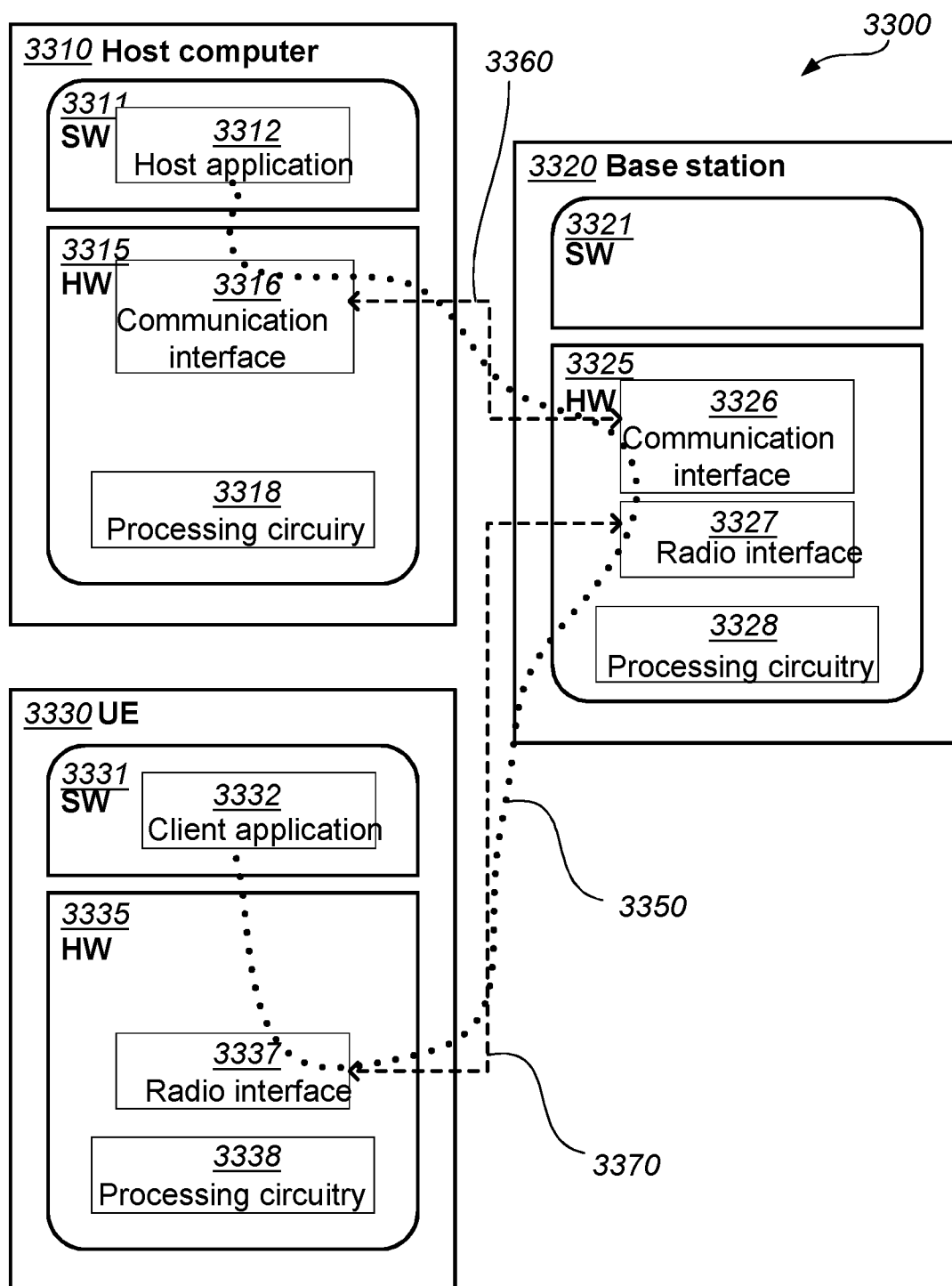
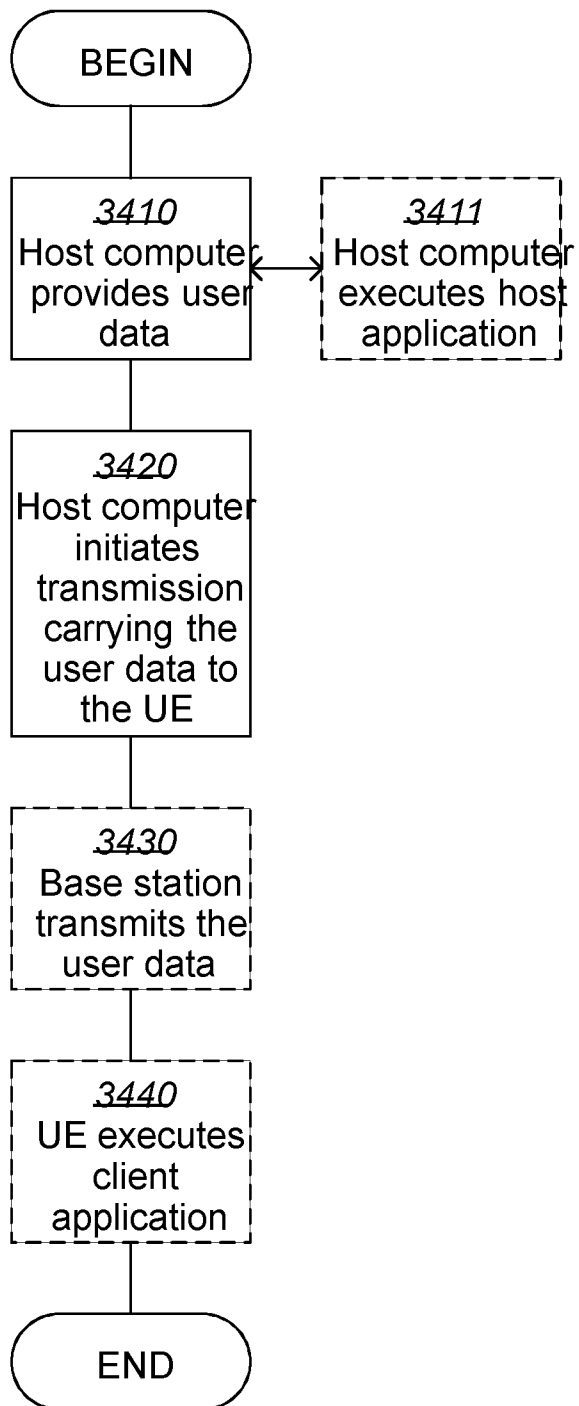
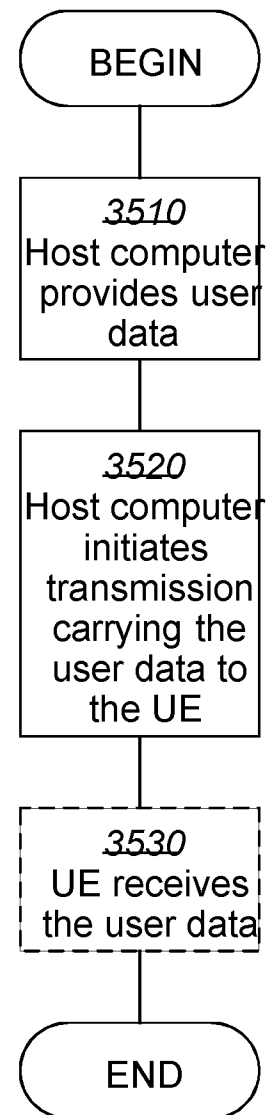
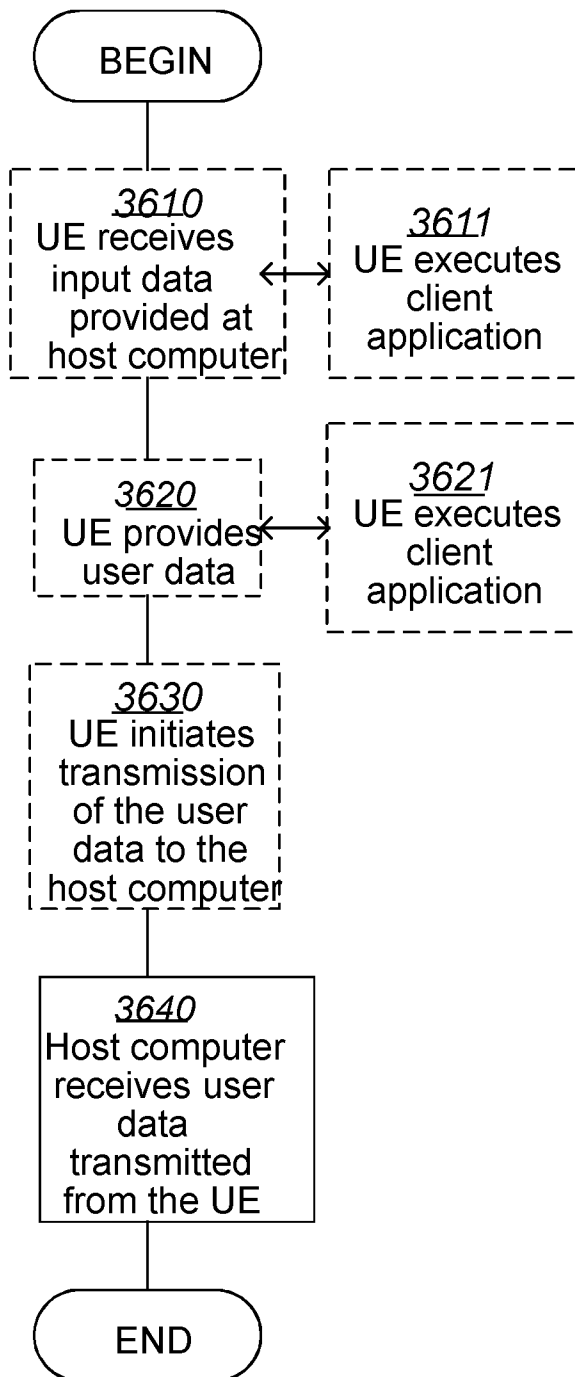
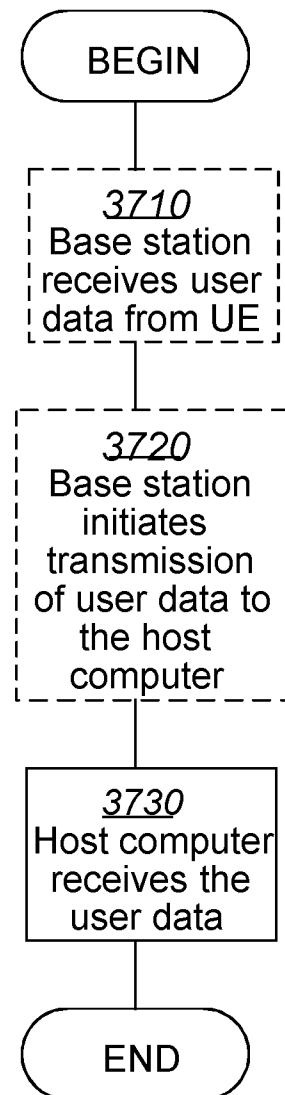


FIG 12

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**FIG.13****FIG.14**

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**FIG 15****FIG 16**

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2019/050595

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/08 H01Q3/26 H04B17/21
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)

H04B H04W H01Q

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

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A	US 2010/015928 A1 (TAKANO HIROAKI [JP] ET AL) 21 January 2010 (2010-01-21) paragraphs [0002], [0003], [0006], [0017], [0027], [0067], [0070]; figure 1 paragraphs [0097], [0102], [0104]; figure 5 -----	1-18
A	CN 102 647 240 B (DATANG MOBILE TECHNOLOGIES CO) 18 November 2015 (2015-11-18) machine translation; paragraphs [0001], [0016], [0017], [0069], [0141]; figures 3,8 ----- -/--	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

23 January 2020

Date of mailing of the international search report

04/02/2020

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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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