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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
07 December 2017 (07.12.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/207308 A1

(51) International Patent Classification:
*H04W 36/30* (2009.01) *H04W 48/20* (2009.01)

(21) International Application Number:
PCT/EP2017/062204

(22) International Filing Date:
22 May 2017 (22.05.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
16290096.3 31 May 2016 (31.05.2016) EP

(71) Applicant: **ALCATEL LUCENT** [FR/FR]; 148/152 route de la Reine, 92100 Boulogne-Billancourt (FR).

(72) Inventors: **AL-NAHHAL, Ibrahim**; Copernicuslaan 50, 2018 Antwerpen (BE). **GACANIN, Haris**; Copernicuslaan 50, 2018 Antwerpen (BE).

(74) Agent: **ALU ANTW PATENT ATTORNEYS**; Copernicuslaan 50, 2018 Antwerp (BE).

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

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

(54) Title: CHANNEL-SELECTION FOR A WIRELESS ACCESS POINT

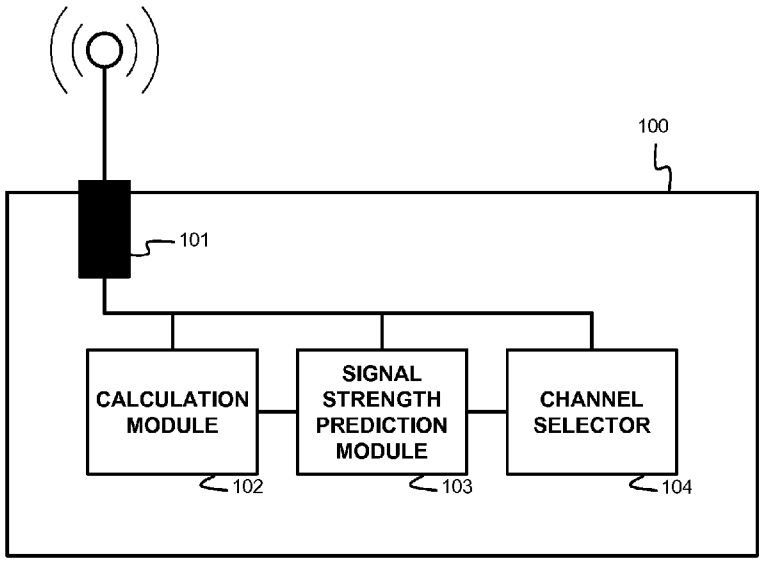



Fig. 1

(57) Abstract: According to an embodiment an apparatus is disclosed for channel selection for a wireless access point. The apparatus is configured to perform the following steps: receiving channel measurements and derive therefrom signal strength levels; and predicting future signal strength levels based on the signal strength levels; and selecting a wireless channel based on the predicted future signal strength levels.

[Continued on next page]

WO 2017/207308 A1

**Published:**
— *with international search report (Art. 21(3))*

# CHANNEL SELECTION FOR A WIRELESS ACCESS POINT

## Field of the Invention

**[01]** The present invention relates to the field of channel selection of a wireless access point.

## Background of the Invention

**[02]** A wireless access point, AP, operating according to the IEEE 802.11 Wi-Fi standard may exhibit performance loss caused by interference. Interference can originate from other APs or wireless devices in general that operate in the same or neighbouring frequency bands. The performance loss typically results in a loss of bandwidth and higher power consumption.

**[03]** A Wi-Fi AP can operate within a selection of channels each characterized by a certain frequency band. In order to optimize its throughput, an AP may select a channel in which it exhibits the least interference.

## Summary of the Invention

**[04]** A way to select the most optimal channel is through a selection process that scans the environment of the AP. This selection process is based on a single measurement in time from which information about the optimal channel is derived. This information relates to the available bandwidth in the channels. Hence, through the measurement the availability of bandwidth in each channel at the measuring time is known. Consequently, it can be decided which channel has the most effective performance. This channel will then be selected.

**[05]** It is however a drawback that the decision is based on a measurement taken at one certain moment in time, the measuring time, because it does not take into account the dynamically changing environment.

**[06]** It is therefore an objective of the present invention to alleviate the above drawback and to provide an improved solution for selecting a wireless channel of an AP.

**[07]** This object is achieved, in a first aspect, by an apparatus for selection of a wireless channel of a wireless access point, the apparatus comprising a calculation module configured to receive channel measurements and to derive therefrom signal strength levels of channels of the AP; and a signal strength prediction module configured to predict future signal strength levels.

**[08]** The calculation module is configured to receive channel measurements. This implies the module scans the environment of the AP and information related to the channels is obtained. Since it will derive from the measurements signal strength levels of channels of the AP, data is collected related to the available bandwidth in each channel. Next, based on the signal strength levels, a signal strength prediction module will predict future signal strength levels of each channel of the AP. These future signal strength levels are again related to the available bandwidth in each channel. Hence, a channel can be selected based on the measurements and the made predictions proceeding from these measurements.

**[09]** It is an advantage that the selection process of a channel of an AP is not only based on the measurements taken at one certain moment in time but is combined with predicted signal strength levels proceeding from these measurements. This responds to the dynamically changing environment and as a result a channel with potentially optimal bandwidth is selected. Furthermore, it is also an advantage that this results in less power consumption of the AP.

**[10]** According to an embodiment, the channel measurements are received signal strength indication, RSSI, levels.

**[11]** The RSSI levels are included in the IEEE 802.11 Wi-Fi standard and measured in dBm. Therefore they indicate the strength of the signal for each channel of the AP.

**[12]** It is an advantage that the channel measurements are RSSI levels because they immediately indicate the signal strength level. Consequently, a standard value can be used and no computation from a measurement to a signal strength level is needed

**[13]** According to an embodiment, the calculation module is further configured to receive the channel measurements from the AP and/or one or more devices connected to the AP.

**[14]** The calculation module receives a multitude of measurements by different devices. These measurements can be either directly RSSI levels or can be converted into signal strength levels. These different signal strength levels, immediately received or derived from the measurements of the different devices can then be used to predict future signal strength levels.

**[15]** It is an advantage that the predicted future signal strength levels of the channels will be more precise since not only a measurement from one device is used but different measurements received from a multitude of devices.

**[16]** According to an embodiment, the calculation module is further configured to average for each channel the signal strength levels derived from the channel measurements received from the AP and/or one or more devices connected to the AP.

**[17]** Since the signal strength levels per channel are averaged, the signal strength prediction module can predict the future signal strength levels for each channel by the use of one value per channel

**[18]** It is an advantage that the signal strength prediction module can operate with one value of a signal strength level per channel in order to predict future signal strength levels, since the prediction can be performed faster due to the necessity of less computation time.

**[19]** According to an embodiment, the signal strength prediction unit is configured to predict a future signal strength level for each channel using linear prediction coding.

**[20]** Since the signal strength prediction unit is configured to predict a future signal strength level for each channel using linear prediction coding, the predicted values are not only based on one measurements but on a number of previous measured values.

**[21]** Since previous measured values are illustrative to the changing environment, and because they are used to predict future signal strength levels, the predicted values anticipate to this changing environment. This way, it is an advantage that the predicted values will be more precise.

**[22]** According to an embodiment, the signal strength prediction module is further configured to predict a future signal strength level for each consecutive future time period, the sample time period, within a forthcoming time period, the channel period.

**[23]** In other words, the signal strength prediction module can not only predict one future signal strength level per channel but can predict a number of future signal strength levels for the forthcoming channel period.

**[24]** It is an advantage that a number of future signal strength levels per channels are predicted for the forthcoming channel period since not only the changing of the environment for a sample period is taken into account but for that of a whole channel period.

**[25]** According to an embodiment, the signal strength prediction module is further configured to average the predicted future signal strength levels for the forthcoming channel period per channel, thereby obtaining an average future level.

**[26]** In this way, one future signal strength level per channel is calculated by averaging the predicted signal strength values of each sample period for the forthcoming channel period.

**[27]** By averaging the predictions over the whole channel period, it is an advantage that the changing of the environment over the whole channel period is taken into account. The outcome is one predicted future signal strength level per channel.

**[28]** According to an embodiment, the channel selector is further configured to select a channel with the highest value of the average future level.

**[29]** Thus, per channel one value is computed by the signal strength prediction unit, in particular an average future signal strength level. Each channel period the channel selector will compare the current channel with the channel that has the highest predicted signal strength level. If the current channel is different than the channel with the highest predicted signal strength level, the channel selector will select the latter one.

**[30]** Since the channel with the highest predicted signal strength level is selected it is an advantage that the availability of bandwidth will increase for the forthcoming channel period and consequently less power will be consumed during the operation of the AP.

**[31]** According to a second aspect the disclosure relates to a method for selecting a wireless channel of an AP, the method comprising receiving channel measurements and deriving therefrom signal strength levels of the AP; and predicting future signal strength levels of the channels based on the signal strength levels; and selecting the wireless channel based on the predicted future signal strength levels.

**[32]** According to a third aspect, the disclosure relates to a computer program product comprising computer-executable instructions for performing the method according to the second aspect when the program is run on a computer.

**[33]** According to a fourth aspect, the disclosure relates to a computer readable storage medium comprising the computer program product according to the third aspect.

**[34]** According to a fifth aspect, the disclosure relates to a data processing system programmed for carrying out the method according to the second aspect.

## Brief Description of the Drawings

**[35]** Fig. 1 illustrates an apparatus for channel selection of a wireless access point according to an embodiment of the invention;

**[36]** Fig. 2 illustrates a system wherein a plurality of devices are connected to a wireless access point while the access point is operating in the proximity of other wireless access points according to an embodiment of the invention; and

**[37]** Fig. 3 illustrates steps performed by an apparatus for channel selection of a wireless access point according to an embodiment of the invention; and

**[38]** Fig. 4 shows an illustrative example of signal strength levels and predicted future signal strength levels of two channels of a wireless access point according to an embodiment of the invention.

## Detailed Description of Embodiment(s)

**[39]** According to an embodiment, the invention relates to an apparatus for selection of a wireless channel of a wireless access point (AP), which can be used for example for a Wireless Local Area Network (WLAN). Figure 1 illustrates such an apparatus 100, comprising a calculation module 102, a signal strength prediction module 103 and a channel selector 104. The apparatus 100 also comprises a network interface 101. Via this network interface 101, the calculation module 102 is configured to receive channel measurements. By these channel measurements, the calculation module 102 will derive signal strength levels of channels of the AP. According to an embodiment of the invention, the measurements can also be directly received signal strength indication, RSSI, levels. Subsequently, the signal strength prediction module 103 is configured to predict future signal strength levels within channels of the AP. These predicted future signal strength levels are based on the signal strength levels derived or directly received as RSSI levels by the calculation module 102. Next, the channel selector 104 of the apparatus 100 will select a channel for the AP based on the future signal strength levels predicted by the signal strength prediction module 103.

**[40]** Wireless access points are commonly working as a system together with other devices which are operating in the same or neighbouring frequency bands. Figure 2 is an illustration of such a system comprising an AP according to an embodiment of the invention. Different APs are presented, such as AP 200. Diverse devices can be connected 202 to AP 200, such as a smartphone 204, a tablet 203 or a laptop 205. Since other APs like 206, with connected devices 208 and 209, and AP 207, with connected devices 210 and 211, may operate in the same channel of AP 200, they may interfere 201 with AP 200. Inference means one or more APs are operating in the same of neighbouring frequency bands as that one of the AP 200. Due to this interference, a decreased performance of the AP 200 can occur resulting in for example a loss of bandwidth and/or higher power consumption. Hence the apparatus 100 will select 104 a channel for the AP 200 in order to optimize its performance, i.e. a channel with a potentially optimal bandwidth is selected.

**[41]** Figure 3 illustrates steps performed by the apparatus 100 in order to select a channel of, for example, the AP 200 with potentially optimal bandwidth according to an embodiment of the invention. At the start 300 the apparatus will record 301 samples. These samples are channel measurements received 101 by the calculation module 102. These measurements can be received from the AP 200 itself, but also from devices connected 202 to the AP 200, such as a smartphone 204, a tablet 203 or a laptop 205. The calculation module 102 will collect and schedule the channel measurements received from the AP 200 and devices 203, 204 and 205. The channel measurements can for example be received signal strength indications (RSSI) levels. Per channel these RSSI levels are then averaged resulting a signal strength level per channel of the AP. This step will be repeated each unit time period, the sample time period.

**[42]** After a predetermined unit time period T, referred as the channel period, the signal strength prediction module 103 will start to 302 predict 303 samples by use of the recorded 301 samples. These predicted samples 303 are thus estimated future signal strength levels and are predicted for each channel of the AP. Thus, a prediction is made for each channel and for each consecutive future sample period during the forthcoming channel period T. As a result, a number of predicted samples are

computed per channel which correspond to future signal strength levels. This operation is executed in step 303.

**[43]** In order to predict future signal strength levels, the signal strength prediction module 103 can be, for example, configured to use linear prediction coding (LPC). The principle of LPC is as follow. The predicted sample at a time $n$ is presented as $\hat{x}(n)$, while the previous recorded samples are presented as $x(n-i)$. In order to predict $\hat{x}(n)$, predictor coefficients are needed and presented as $a_i$. Hence, the LPC filter can predict the future sample by the following equation:

$$\hat{x}(n) = \sum_{i=1}^{P} a_i x(n-i) \qquad \text{(Eq. 1)}$$

wherein P is the order of the LPC filter and $n$ is a discreet time moment. The predictor coefficients $a_i$ can be determined using $n-1$ recorded samples by solving the following equation:

$$\begin{bmatrix} r(0) & r(1) & \cdots & r(P-1) \\ r(1) & r(0) & \cdots & r(P-2) \\ \vdots & \vdots & \ddots & \vdots \\ r(P-1) & r(P-2) & & r(0) \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_P \end{bmatrix} = \begin{bmatrix} r(1) \\ r(2) \\ \vdots \\ r(P) \end{bmatrix} \qquad \text{(Eq. 2)}$$

wherein $r(i)$ represents an autocorrelation coefficient and can be calculated by shifting samples by $i$ steps as follows:

$$r(i) = \sum_{k=0}^{n-i-1} x(k)x(k+i) \qquad \text{(Eq. 3)}$$

wherein $k$ is the number of the sample. Accordingly by combining Eq. 1, 2 and 3, a sample can be predicted for the first future sample period.

**[44]** Subsequently, the predicted future sample for the first future sample period is considered as a recorded sample for calculating a future sample for the second future sample period. Thus, by again combining Eq. 1, 2 and 3, by shifting the time moment and by considering the previous predicted sample as a recorded sample, a sample for the second future sample period can be predicted. This procedure will be repeated in order to predict samples for the whole forthcoming channel period T. As a result $m$ predicted samples per channel for the forthcoming channel period are computed, wherein $m$ equals to the ratio of the channel period T over the sample period.

**[45]** The $m$ predicted future samples per channel for the forthcoming channel period are then averaged by the signal strength prediction module 103, thereby obtaining an average future level $I_c$ per channel. This step is performed in 304 wherein the following equation is used

$$I_c = \frac{\sum_{i=0}^{m-1} \hat{x}(n+i)}{m}. \qquad \text{(Eq. 4)}$$

**[46]** In the next step 305 the optimal channel (OC) is determined by identifying the channel which has the highest value of the calculated average future signal strength level. This channel is the OC for the forthcoming channel period.

**[47]** The current channel (CC) is compared with the just determined OC. This is done in step 306. If the CC is different from the OC the channel will be changed to the OC 307. Afterwards, the procedure is repeated. If the CC is the same as the OC the channel will not be changed, and again the procedure is repeated.

**[48]** Figure 4 shows a graph with measured signal strength levels and predicted signal strength levels as a function of time of two channels 400 and 401 according to an embodiment of the present disclosure. At a certain moment in time n for each channel 400 and 401 a number of RSSI levels have been previously measured and are expressed in dBm. For example for channel 401 a measured RSSI level is presented as 402. These RSSI levels have been measured each sample time period and the sample time period is presented as λ 405.

**[49]** The channel period T 404, according to an embodiment of the invention, can for example be 15 minutes while the sample time period can be 3 minutes. This results in 5 predicted future signal strength levels per channel each channel period T.

**[50]** The order P of the LPC filter, according to an embodiment of the invention, can for example be equal to 3.

**[51]** An optimum number of samples used to predict the future signal strength levels, according to embodiment of the invention, is in the range between 30 and 50.

**[52]** At time n, which corresponds to the end of a previous channel period and the start of a forthcoming channel period, presented as 404, the signal strength prediction module 103 will predict 303 future signal strength levels for the forthcoming channel period T 404. An example of a predicted future signal strength level is presented as 403 for channel 401 and as 406 for channel 400.

**[53]** A future signal strength level is predicted for each sample time period λ 405 for a forthcoming channel period T. These predictions are made at time n. For each channel 400 and 401 the predicted future signal strength levels are then averaged, presented as, for example, 407 for channel 400.

**[54]** Thus, at time n an average predicted future signal strength level is calculated. Next, at the same moment in time n the channel selector will select the channel with the highest value of the predicted future signal strength levels. This channel will be used by the AP for the forthcoming channel period T 404.

**[55]** Although the present invention has been illustrated by reference to specific embodiments, it will be apparent to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments, and that the present invention may be embodied with various changes and modifications without departing from the scope thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein. In other words, it is contemplated to cover any and all modifications, variations or equivalents that fall within the scope of the basic underlying principles and whose essential attributes are claimed in this patent application. It will furthermore be understood by the reader of this patent application that the words "comprising" or "comprise" do not exclude other elements or steps, that the words "a" or "an" do not exclude a plurality, and that a single element, such as a computer system, a processor, or another integrated unit may fulfil the functions of several means recited in the claims. Any reference signs in the claims shall not be construed as limiting the respective claims concerned. The terms "first", "second", third", "a", "b",

"c", and the like, when used in the description or in the claims are introduced to distinguish between similar elements or steps and are not necessarily describing a sequential or chronological order. Similarly, the terms "top", "bottom", "over", "under", and the like are introduced for descriptive purposes and not necessarily to denote relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and embodiments of the invention are capable of operating according to the present invention in other sequences, or in orientations different from the one(s) described or illustrated above.

## CLAIMS

1. Apparatus (100) for selection of a wireless channel of a wireless access point, AP (200), the apparatus comprising:

a) a calculation module (102) configured to receive (101) channel measurements and to derive therefrom signal strength levels of channels of the AP; and

b) a signal strength prediction module (103) configured to predict future signal strength levels of the channels based on the signal strength levels; and

c) a channel selector (104) adapted to select the wireless channel based on the predicted future signal strength levels.

2. Apparatus according to claim 1, wherein the channel measurements are received signal strength indications, RSSI, levels.

3. Apparatus according to any one of the preceding claims, wherein the calculation module is further configured to receive the channel measurements from the AP (200) and/or one or more devices (203, 204, 205) connected to the AP.

4. Apparatus according to claim 3, wherein the calculation module is further configured to average for each channel the signal strength levels derived from the channel measurements received from the AP and/or one or more devices connected to the AP.

5. Apparatus according to any one of the preceding claims, wherein the signal strength prediction module is further configured to predict a future signal strength level (403, 407) for each channel by linear prediction coding.

6. Apparatus according to claim 5, wherein the signal strength prediction module is further configured to predict a future signal strength level for each consecutive future time period, the sample time period (405), within a forthcoming time period, the channel period (404).

7. Apparatus according to claim 6, wherein the signal strength prediction module is further configured to average the predicted future signal strength levels for the forthcoming channel period per channel, thereby obtaining an average future level.

8. Apparatus according to claim 7, wherein the channel selector is further configured to select a channel with the highest value of the average future level.

9. Apparatus according to any one of the preceding claims whereby the number of samples used to predict the future signal strength levels is in the range between 30 and 50.

10. Method for selecting a wireless channel of a wireless access point, AP (200), the method comprising:

d) receiving channel measurements and deriving therefrom signal strength levels of channels of the AP; and
e) predicting future signal strength levels of the channels based on the signal strength levels; and
f) selecting the wireless channel based on the predicted future signal strength levels.

11. A computer program product comprising computer-executable instructions for performing the method according to claim 10 when the program is run on a computer.

12. A computer readable storage medium comprising the computer product according to claim 11.

13. A data processing system programmed for carrying out the method according to claim 10.

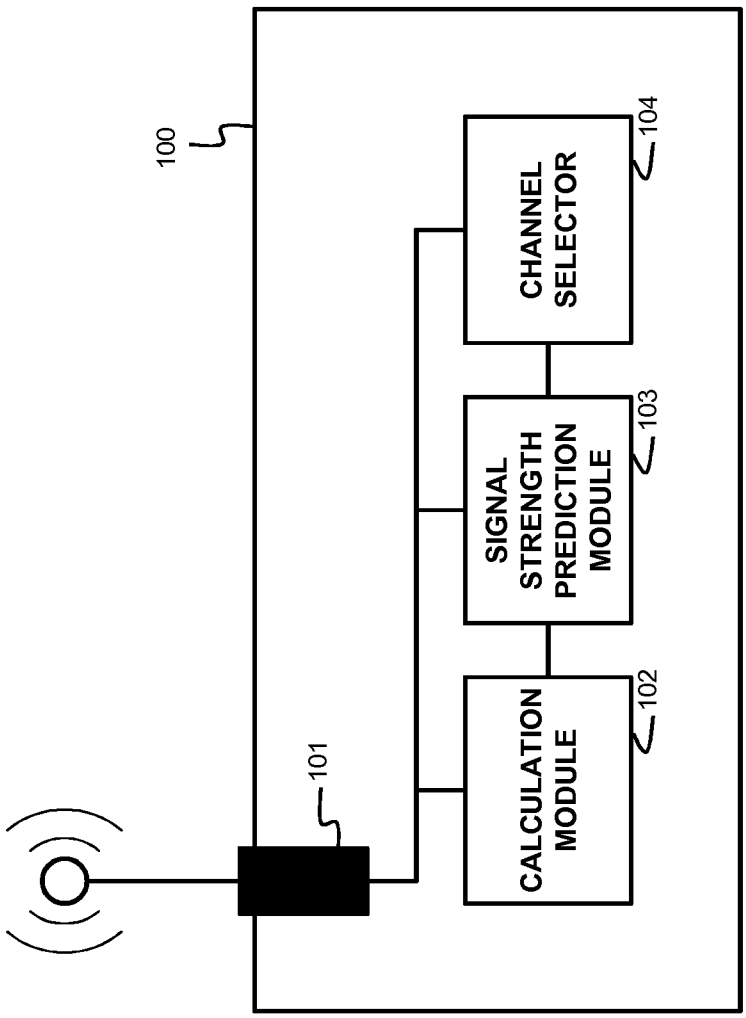

100
101
CALCULATION MODULE
102
SIGNAL STRENGTH PREDICTION MODULE
103
CHANNEL SELECTOR
104

Fig. 1

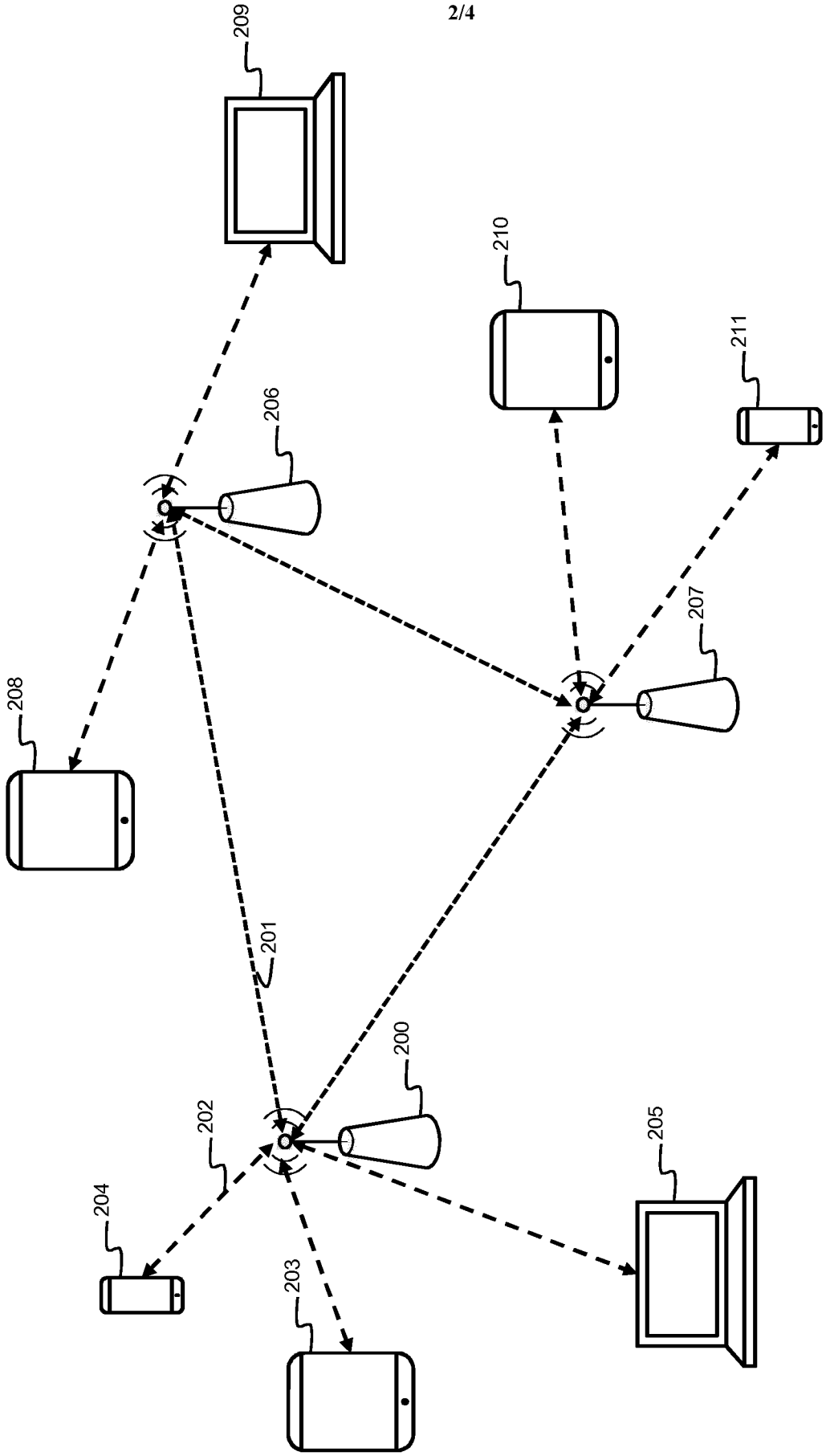



Fig. 2

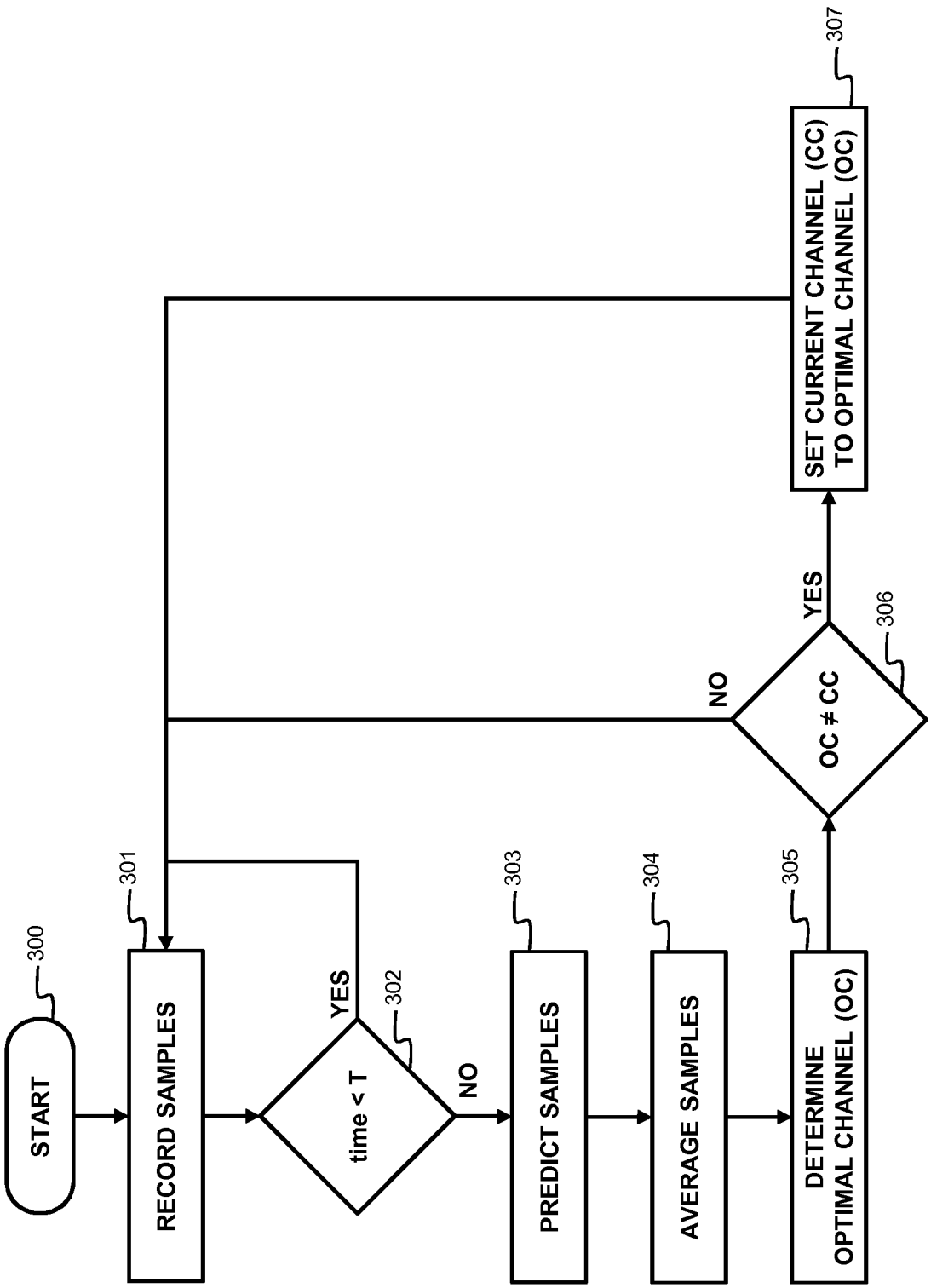

START
300
RECORD SAMPLES
301
time < T
YES
302
NO
PREDICT SAMPLES
303
AVERAGE SAMPLES
304
DETERMINE OPTIMAL CHANNEL (OC)
305
OC ≠ CC
306
NO
YES
SET CURRENT CHANNEL (CC) TO OPTIMAL CHANNEL (OC)
307

Fig. 3

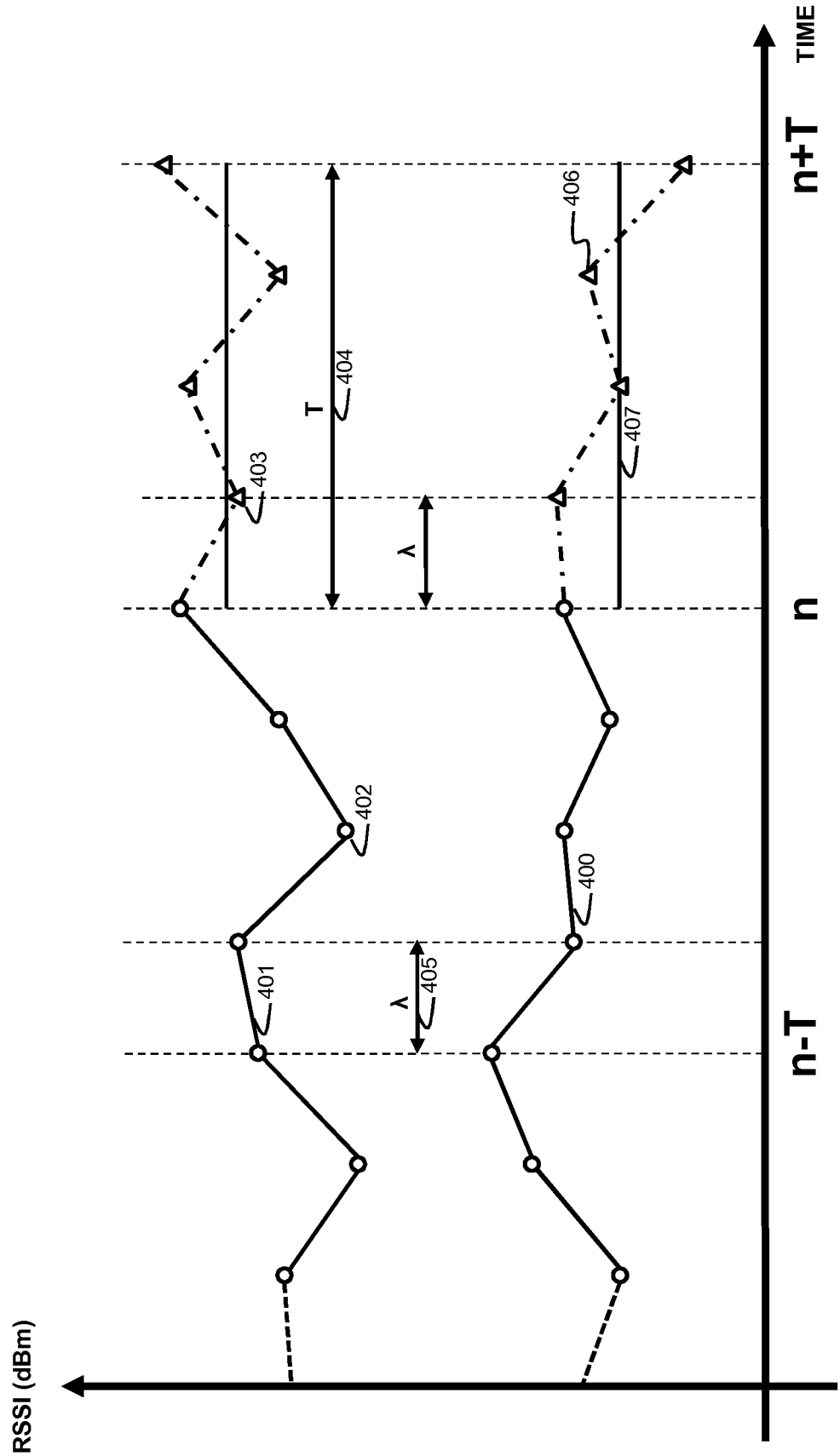



Fig. 4

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/062204

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W36/30 H04W48/20
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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>Y | US 8 089 939 B1 (MATER OLAF [DE] ET AL)<br>3 January 2012 (2012-01-03)<br>column 2, line 13 - line 21<br>column 7, line 3 - line 7<br>column 5, line 11 - line 16<br>column 9, line 17 - line 21<br>column 6, line 40 - line 43<br>column 3, line 30 - line 33<br>column 8, line 6 - line 14<br>column 2, line 45 - line 48<br>----- | 1,2,4,5,<br>10-13<br>3,6-9 |
| X | EP 2 046 082 A1 (BRITISH TELECOMM [GB])<br>8 April 2009 (2009-04-08)<br>paragraph [0028]; figure 6<br>----- | 1,2,<br>10-13 |
| Y | US 2011/044177 A1 (NAIR BIJU [US] ET AL)<br>24 February 2011 (2011-02-24)<br>page 2, paragraphs 18,21<br>----- | 3 |
| | -/-- | |

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 13 June 2017 | 26/06/2017 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Koutsopoulou, E |

2

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

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | KANNAN G ET AL: "An Efficient Feedback Active Noise Control Algorithm Based on Reduced-Order Linear Predictive Modeling of fMRI Acoustic Noise", IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, IEEE SERVICE CENTER, PISCATAWAY, NJ, USA, vol. 58, no. 12, 1 December 2011 (2011-12-01), pages 3303-3309, XP011408573, ISSN: 0018-9294, DOI: 10.1109/TBME.2010.2096423 page 1, column 2 page 3, columns 1,2 | 6-9 |
| A | US 2008/019324 A1 (MATSUMOTO AKIRA [JP] ET AL) 24 January 2008 (2008-01-24) page 13; claims 1,2,4,7 | 1,10-13 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/062204

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 8089939 B1 | 03-01-2012 | NONE | |
| EP 2046082 A1 | 08-04-2009 | NONE | |
| US 2011044177 A1 | 24-02-2011 | US 2011044177 A1 | 24-02-2011 |
| | | WO 2011022701 A1 | 24-02-2011 |
| US 2008019324 A1 | 24-01-2008 | JP 5084373 B2 | 28-11-2012 |
| | | JP 2008042896 A | 21-02-2008 |
| | | US 2008019324 A1 | 24-01-2008 |