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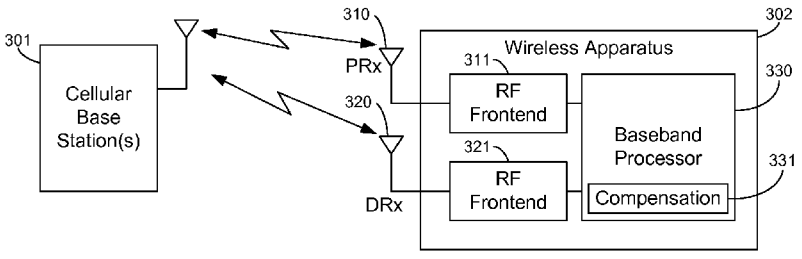


Fig. 3

(57) Abstract: The present disclosure includes systems and methods for acquiring service using multiple channels. In one embodiment, the present invention includes a method comprising successively configuring a first wireless communication channel and a second wireless communication channel of a single wireless apparatus to receive a plurality of signal frequencies of one or more radio communication protocols. The first wireless communication channel is configured to receive different signal frequencies of the plurality of signal frequencies than the second wireless communication channel. The first wireless communication channel and the second wireless communication channel process the plurality of signal frequencies in parallel to establish a service connection.

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SYSTEMS AND METHODS FOR ACQUIRING SERVICE USING MULTIPLE CHANNELS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Nonprovisional App. No. 14/067,636 filed October 30, 2013, the content of which is incorporated herein by reference in its entirety for all purposes.

BACKGROUND

[0002] The present disclosure relates to wireless systems and methods, and in particular, to systems and methods for acquiring service using multiple wireless communication channels.

[0003] Typical wireless communication systems include two systems in different locations that communicate information using radio frequency signals that propagate through the air. In order to communicate such information, the two wireless systems must establish a connection. In cellular applications, the process of establishing a connection between a wireless handset and a cellular base station is sometimes referred to as service acquisition.

[0004] Fig. 1 illustrates service acquisition between a cellular base station 101 and a cellular phone 102. Cellular base station 101 may transmit one or more radio access technologies ("RATs") (herein, "radio communication protocols"). Examples of such protocols include, but are not limited to, GSM, WCDMA, or LTE protocols. Accordingly, one or more cellular base stations in a region may transmit a variety of signal frequencies 150 corresponding to the various protocols available for a cellular phone to use to establish a service connection. When cellular phone 102 is turned on the system may initiate a service acquisition procedure by examining the signal frequencies for one or more radio communication protocols received on antenna 104.

[0005] Fig. 2 illustrates a problem with existing service acquisition techniques. A receive channel 200 includes an antenna 250, RF front end 201, and baseband 202. Antenna 250 couples RF signals from the air to an input of RF frontend 201. RF frontend 201 typically includes an input amplifier, demodulator, and analog-to-digital

converter to receive the RF signals and generate a digital representation of the demodulated signals, which typically include many signal frequencies configured around a carrier frequency. Baseband 202 receives digital demodulated signals (e.g., without the carrier frequency) and may analyze the received signal frequencies in an attempt to identify the presence of one of the radio communication protocols.

[0006] However, since different radio communication protocols typically use different carrier frequencies and different encodings of the signal frequencies, a wireless communication channel must be configured to receive and decipher one particular radio communication protocol at a time. As illustrated in the receive channel 220, a wireless communication channel may first be configured to receive each particular GSM band, then particular WCDMA bands, then particular LTE bands and/or other available radio communication protocols to determine if any of the radio communication protocols are available for establishing a service connection. Accordingly, existing techniques for performing service acquisition can be extremely time consuming.

SUMMARY

[0007] The present disclosure includes systems and methods for acquiring service in a wireless system. In one embodiment, the present invention includes a method comprising successively configuring a first wireless communication channel and a second wireless communication channel of a wireless apparatus to receive a plurality of signal frequencies of one or more radio communication protocols. The first wireless communication channel is configured to receive different signal frequencies of the plurality of signal frequencies than the second wireless communication channel. The first wireless communication channel and the second wireless communication channel process the plurality of signal frequencies in parallel to establish a service connection.

[0008] The following detailed description and accompanying drawings provide a better understanding of the nature and advantages of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figs. 1-2 illustrate an existing wireless system acquiring a service connection.

[0010] Fig. 3 illustrates wireless communication channels establishing a service connection according to one embodiment.

[0011] Fig. 4 illustrates performing service acquisition in parallel using multiple wireless communication channels according to one example embodiment.

[0012] Fig. 5 illustrates a method according to one example embodiment.

[0013] Fig. 6 illustrates compensating two channels for different path losses according to one embodiment.

[0014] Fig. 7 illustrates compensation according to an example embodiment.

[0015] Fig. 8 illustrates an example service acquisition process according to another embodiment.

DETAILED DESCRIPTION

[0016] The present disclosure pertains to systems and methods for acquiring service in a wireless system. In the following description, for purposes of explanation, numerous examples and specific details are set forth in order to provide a thorough understanding of the present disclosure. It will be evident, however, to one skilled in the art that the present disclosure as expressed in the claims may include some or all of the features in these examples alone or in combination with other features described below, and may further include modifications and equivalents of the features and concepts described herein.

[0017] Fig. 3 illustrates wireless communication channels establishing a service connection according to one embodiment. Embodiments of the present disclosure include successively configuring a plurality of wireless communication channels on a single wireless apparatus 302 to simultaneously receive a plurality of signal frequencies of a radio communication protocol, such as GSM, WCDMA, or LTE, for example.

[0018] In one embodiment, a primary channel may be configured to receive one radio communications protocol (e.g., WCDMA) and a diversity channel may be configured to receive another radio communications protocol (e.g., LTE). In yet another embodiment, a primary channel may be configured to receive a particular band of a radio communications protocol (e.g., GSM) and a diversity channel may be configured to receive another band of the same radio communications protocol. In yet another embodiment, a primary channel may be configured to receive a particular signal frequency (e.g., a frequency encoded with information in a band of frequencies) for a

particular radio communications protocol (e.g., GSM) and a diversity channel may be configured to receive a signal frequency of the same band of the same radio communications protocol.

[0019] In this example, wireless apparatus 302 includes two antennas 310 and 320 for a primary receive channel (PRx) and diversity receive channel (DRx). Antenna 310 is coupled to RF frontend 311, which receives RF signals and outputs digital representations of demodulated signals to a baseband processor 330. Similarly, antenna 320 is coupled to RF frontend 321, which receives RF signals and outputs digital representations of demodulated signals to a baseband processor 330. In certain embodiments, different wireless communication channels may be configured to receive different signal frequencies. In this example, RF frontend 311 and RF frontend 321 may be configured to receive different radio communication protocols, different bands of the same protocol, or different signal frequencies in the same band of the same protocol, for example. Accordingly, different wireless communication channels may process signal frequencies in parallel to reduce the time required to establish a service connection.

[0020] In one embodiment, a wireless apparatus includes a compensation component 331 (e.g., in the baseband) to compensate the wireless communication channels for different path losses. As described in more detail below, compensating may include configuring the wireless communication channels to receive the same signal frequency to produce compensation factors. The compensation factors may be applied to detected signals to compensate for different path losses between a transmitting system, such as cellular base station(s) 301, and one or more antennas, such as PRx antenna 310 and DRx antenna 320, for example. In one embodiment described in more detail below, one wireless communication channel may be used as a reference channel, and detected values for all the other wireless communication channels are adjusted to compensate for path loss differences with the reference channel, for example.

[0021] Fig. 4 illustrates performing service acquisition in parallel using multiple wireless communication channels according to one example embodiment. As illustrated in Fig. 4, service acquisition of the protocols is carried out in parallel using both the PRx path 401 and the DRx path 402. Accordingly, the time to acquire service may be reduced drastically.

[0022] Fig. 5 illustrates a method according to one example embodiment. At 501, a plurality of wireless communication channels may be successively configured to receive different signal frequencies. For example, in one embodiment, a primary channel may be configured to receive a particular signal frequency (e.g., a frequency encoded with information in a band of frequencies) for a particular radio communications protocol (e.g., GSM) and a diversity channel may be configured to receive signal frequency of the same band of the same radio communications protocol. The different channels may be successively configured to process particular signal frequencies in parallel to establish a service connection, for example.

[0023] At 502, the wireless communication channels may be compensated. For example, in one embodiment described in more detail below, the wireless communication channels are configured to receive the same signal frequency so that the system may compensate for different path losses between a transmitter and different antennas. At 503, signal frequency energies or equivalent signal values are detected in parallel. For example, in one embodiment a primary channel may detect half the frequencies in a band and a diversity channel may detect the other half of the frequencies in the band at the same time. At 504, the system may sort the detected energies (e.g., descending from strongest). At 505, the system may successively attempt to establish a service connection at each frequency starting with the signal frequency at the top of the sorted list, for example.

[0024] Fig. 6 illustrates compensating two channels for different path losses according to one embodiment. As mentioned above, in some embodiments a wireless system may process signal frequencies in parallel on two channels and compensate the results for different path losses. In this illustrative example, a transmitter 601 transmits a signal that is received by a primary receive channel 604 and a secondary receive channel 605. However, the same signal is received by the two channels with different strengths because of the different physical locations of the two channel's antenna. Accordingly, a signal propagating from transmitter 601 to primary receive channel 604 may undergo fading 602 (e.g., a first path loss), and the same signal propagating from transmitter 601 to secondary receive channel 605 may undergo different fading 603 (e.g., a second path loss). A compensation component 606 receives the detected signal values (e.g., energy) and corrects the signal values to compensate for differences in path loss.

[0025] Fig. 7 illustrates compensation according to an example embodiment. In this example, a radio communication protocol may have a particular band (B1) including N frequencies f1…fN. As illustrated at 700A in Fig. 7, primary wireless communication channel (P) 701 and diversity wireless communication channel (D) 702 may be configured to receive one or more of the same signal frequencies. For example, channels 701 and 702 may both be configured to receive the same one or more of the frequencies from B1. In this case, channels 701 and 702 both receive fi, fj, and fk, for example. Channel 701 may detect and produce energies for each frequency: Pout = $\{E_{Pi}, E_{Pj}$, and $E_{Pk}\}$ (e.g., and additional outputs if more frequencies are used). Similarly, channel 702 may detect and produce energies for each frequency: Dout = $\{E_{Di}, E_{Dj}$, and $E_{Dk}\}$. A variety of techniques may be used for generating one or more compensation factors to compensate for path loss using the outputs of the different channels. In one embodiment, a difference between energy levels from two channels at the same frequency is used to produce a delta value. In this example, computing the difference between signal energy outputs of channels 701 and 702 at frequency fi produces delta_i, computing the difference between signal energy outputs of channels 701 and 702 at frequency fj produces delta_j, computing the difference between signal energy outputs of channels 701 and 702 at frequency fj produces delta_k. The deltas may be averaged to produce a single compensation factor α, for example.

[0026] As illustrated at 700B in Fig. 7, channels 701 and 702 may be configured to receive different signal frequencies in band B1 of a radio communication protocol. For example, channel 701 may receive half of the signal frequencies $f_{P1}…f_{PN/2}$ and channel 702 may receive the other half of the signal frequencies $f_{D1}…f_{DN/2}$. Accordingly, channel 701 outputs Pout = $\{E_{P1i},…, E_{PN/2}\}$ and channel 702 outputs Dout = $\{E_{D1i},…, E_{DN/2}\}$. Each of the detected energy values may be compensated for path loss. For example, compensation factor, α, represents a difference in path loss between channel 701 and 702. Accordingly, each energy value from the diversity channel 702 may be compensated by multiplying the energy value by compensation factor, α (e.g., a final value, E_{Df} equals an initial value E_{Di} times the compensation factor). Accordingly, the signal frequencies received and detected by channel 702 may be compensated for the different path loss during the service acquisition procedure. In one embodiment described in more detail below, one or more of the detected energy levels for the same signal frequencies are signal frequencies in the radio communication protocol (e.g., fi,

fj, or fk) so that the energy levels for these signals determined during compensation may be saved, compensated for, and used in the service acquisition process. Thus, any signal frequencies detected during compensation in 700A can be removed from the signal acquisition process of 700B to further reduce the time of service acquisition.

[0027] Fig. 8 illustrates an example service acquisition process according to another embodiment. In one embodiment, multiple channels may be configured to receive and sample the same frequency as part of the compensation procedure. At 801, multiple wireless communication channels are configured to successively receive multiple samples at one or more selected frequencies. At 802, an average of the samples is determined at each frequency (e.g., an average of sample at frequency fi, fj, and fk at 700A in Fig. 7). At 803, a difference between outputs from the channels at each frequency is determined. For example, as mentioned above, a difference between an average value of samples for frequency fk from channel 701 and an average value of samples for frequency fk from channel 702 may be determined to generate one "delta" (or "difference") value. At 804, the system may produce an average of the difference values across the selected frequencies to produce a compensation factor, for example. At 805, the wireless communication channels are configured to successively receive undetected channels in a band. As mentioned above, since energies for some of the frequencies in the band were determined during compensation, it may be unnecessary to determine energy levels for these frequencies again. At 806, the compensation factor is applied to detected energy levels for the received frequencies. In one example embodiment, detected energy levels from one wireless communication channel are unchanged and detected energy levels from other wireless communication channels are multiplied by a compensation factor. At 807, the system determines if other bands of the current radio communication protocol or other radio communication protocols are to be examined as part of the service acquisition process. If more bands are to be analyzed, then the process returns to 801. If the process is complete, then the energy values produced by each wireless communication channel are sorted at 808. At 809, the system is configured to establish communication with the frequencies in the sorted list.

EXAMPLE

[0028] Aspects of the present disclosure are further understood using the following illustrative example. The specific numbers and details are to be understood as instructive, but not limiting, of the concepts and embodiments described above.

[0029] Advantages of service acquisition using some of the above described techniques may be shown by considering a search of R-GSM 900. R-GSM 900 includes the following channels: 955–1023, 0-124 (i.e., total number of channels = 194). Accordingly, a wireless apparatus may be required to scan 194 channels during a service acquisition procedure. In this example, Band 1 may include frequencies {f1…f194}, and frequencies {f1…f97} may be received by a primary receive channel (PRx) and frequencies {f98…f194} may be received by a secondary (or diversity) receive channel (DRx) on the wireless apparatus. The outputs of the PRx and DRx channels are received energy levels at each frequency as follows:

R^{PRX} = {Rxf1 … Rxf97} – received signal energies from primary channel;

R^{DRX} = {Rxf98 … Rxf194} – received signal energies from diversity channel.

However, due to path loss differences mentioned above, there may be more attenuation in the transmission path between the transmitter antenna and the two different receiver antennas for each channel, causing all the received energy levels to be lower for one channel than the other. For example, if a 20dBm signal is transmitted, but the path loss to the primary channel antenna is -95dBm and the path loss to the diversity channel antenna is -100dBm, then the diversity channel energy levels for each frequency will be -5dBm lower than the primary channel energy levels (e.g., PRx = +20dBm-95dBm = -75dBm and DRx = +20dBm-100dBm = -80dBm). This 5dBm imbalance should be compensated to accurately compare signal energies of the frequencies received by each channel, for example. In some applications, changes in path loss within about 1 second may be negligible, so an entire band (e.g., f1…f194) may be compensated once for service acquisition purposes.

[0030] The following is one example algorithm for performing the compensation.

0: k=1;

1: Select 10 channels per band separated by approximately the same frequency (e.g., f(x) = {f20, f40, f60, f80,…,f180, f190}

2: Configure PRx → f(k); f(1) = f20, f(2)=f40,…, f(10)=f190

3: Configure DRx → f(k); f(1) = f20, f(2)=f40,…, f(10)=f190

//both channels receive same signal frequencies.

4: Sample 5 times per channel;

//PRx_f(k) = [s1, s2, s3, s4, s5];

//DRx_f(k) = [s1', s2', s3', s4', s5'];

5: Average samples on each channel

//PRx[k] = mean(PRx_f(k)); (e.g., PRx[1]=mean(s1…s5))

//DRx[k] = mean(DRx_f(k))

6: Take the difference at each frequency

//delta[k] = PRx[k] – DRx[k]

7: Increment; k = k + 1

8: If k > 10 goto step 10

9: Goto step 2

10: Average delta values across all 10 frequencies

// Compensation factor α = mean(delta[k]; k=1…10)

11: PRx[k] = DRx[k] – α; for all k

12: Successively configure PRx and DRx to remaining 184 frequencies (e.g., 194 total frequencies minus 10 frequencies already completed)

// Configure PRx to {f1…f82}

// Configure DRx to {f83…f184}

13: Measure energy at each frequency in parallel

//PRx = {E1, …, E82}

//DRx = {E83, …, E184}

14: Compensate – PRx = DRx – α

15: Store energy values in list

16: Sort list

17: Perform service acquisition search from top of list.

[0031] The above description illustrates various embodiments of the present disclosure along with examples of how aspects of the particular embodiments may be implemented. The above examples should not be deemed to be the only embodiments, and are presented to illustrate the flexibility and advantages of the particular embodiments as defined by the following claims. Based on the above disclosure and the following claims, other arrangements, embodiments, implementations and equivalents may be employed without departing from the scope of the present disclosure as defined by the claims.

WHAT IS CLAIMED IS:

CLAIMS

1. A method comprising:

successively configuring a first wireless communication channel and a second wireless communication channel of a single wireless apparatus to receive a plurality of signal frequencies of one or more radio communication protocols,

wherein the first wireless communication channel is configured to receive different signal frequencies of the plurality of signal frequencies than the second wireless communication channel, and

wherein the first wireless communication channel and the second wireless communication channel process the plurality of signal frequencies in parallel to establish a service connection.

2. The method of claim 1 wherein the first wireless communication channel is coupled to a first antenna and the second wireless communication channel is coupled to a second antenna.

3. The method of claim 1 wherein successively configuring comprises:

configuring the first wireless communication channel to receive a first signal frequency of the plurality of signal frequencies;

configuring the second wireless communication channel to receive a second signal frequency of the plurality of signal frequencies, wherein the second signal frequency is different than the first signal frequency;

simultaneously processing the first signal frequency in the first wireless communication channel and the second signal frequency in the second wireless communication channel;

performing said configuring the first wireless communication channel step for a first plurality of signal frequencies of the plurality of signal frequencies, performing said configuring the second wireless communication channel step for a second plurality of signal frequencies of the plurality of signal frequencies, and repeating said simultaneously processing step for each of the first and second plurality of frequencies.

4. The method of claim 1 further comprising compensating the first wireless communication channel and the second wireless communication channel to compensate the plurality of signal frequencies received on the first wireless communication channel and the second wireless communication channel for different path losses.

5. The method of claim 4 wherein said compensating comprises:

configuring the first wireless communication channel and the second wireless communication channel to receive one or more same signal frequencies;

detecting each of said same signal frequencies to produce one or more first detected energy levels for the first wireless communication channel and one or more second detected energy levels for the second wireless communication channel; and

modifying a plurality of third detected energy levels of the plurality of signal frequencies received in one of the first wireless communication channel or the second wireless communication channel based on a difference between the first detected energy levels and the second detected energy levels.

6. The method of claim 5 wherein said one or more same signal frequencies are from the plurality of signal frequencies of a single radio communication protocol.

7. The method of claim 5 wherein detecting each of said same signal frequencies comprises:

sampling each of said same signal frequencies in the first wireless communication channel and the second wireless communication channel to produce a first plurality of samples in the first wireless communication channel and a second plurality of samples in the second wireless communication channel; and

generating averages of the first plurality of samples and the second plurality of samples at each of said same signal frequencies.

8. The method of claim 1 wherein the first wireless communication channel is a primary channel and the second wireless communication channel is a diversity channel.

9. The method of claim 8 wherein the primary channel processes a first radio communication protocol and the secondary channel processes a second radio communication protocol.

10. The method of claim 8 wherein the primary channel processes a first band of a particular radio communication protocol and the secondary channel processes a second band of the particular radio communication protocol.

11. An apparatus comprising:

a first wireless communication channel successively configured to receive a first plurality of signal frequencies of a plurality of signal frequencies of one or more radio communication protocols; and

a second wireless communication channel, successively configured to receive a second plurality of signal frequencies of the plurality of signal frequencies of the one or more radio communication protocols, wherein the first wireless communication channel and the second wireless communication channel are part of a single wireless apparatus,

wherein the first wireless communication channel is configured to receive different signal frequencies of the plurality of signal frequencies than the second wireless communication channel, and

wherein the first wireless communication channel and the second wireless communication channel process the plurality of signal frequencies in parallel to establish a service connection.

12. The circuit of claim 11 further comprising a first antenna coupled to the first wireless communication channel and a second antenna coupled to the second wireless communication channel.

13. The circuit of claim 11 wherein the first wireless communication channel is a primary channel and the second wireless communication channel is a diversity channel.

14. The circuit of claim 11 further comprising a compensation component to compensate the first wireless communication channel and the second wireless communication channel to compensate the plurality of signal frequencies

received on the first wireless communication channel and the second wireless communication channel for different path losses.

15. The circuit of claim 14 wherein said compensation component is operable to:

configure the first wireless communication channel and the second wireless communication channel to receive one or more same signal frequencies and detect each of said same signal frequencies to produce one or more first detected energy levels for the first wireless communication channel and one or more second detected energy levels for the second wireless communication channel; and

modify a plurality of third detected energy levels of the plurality of signal frequencies received in one of the first wireless communication channel or the second wireless communication channel based on a difference between the first detected energy levels and the second detected energy levels.

16. The circuit of claim 15 wherein said one or more same signal frequencies are from the plurality of signal frequencies of a signal radio communication protocol.

17. The circuit of claim 15 wherein said compensation component is operable to:

configure the first wireless communication channel and the second wireless communication channel to sample each of said same signal frequencies in the first wireless communication channel and the second wireless communication channel to produce a first plurality of samples in the first wireless communication channel and a second plurality of samples in the second wireless communication channel; and

generate averages of the first plurality of samples and the second plurality of samples at each of said same signal frequencies.

18. A method comprising:

compensating a plurality of wireless communication channels on a single wireless apparatus for different path losses, said compensating comprising configuring the plurality of wireless communication channels to receive a same signal frequency and produce compensation factors;

successively configuring the plurality of wireless communication channels to simultaneously receive a plurality of signal frequencies, wherein the different wireless communication channels are configured to receive different signal frequencies of the plurality of signal frequencies, and wherein the wireless communication channels process the plurality of signal frequencies in parallel to produce a plurality of detected signal values to establish a service connection; and

applying the compensation factors to the detected signal values produced by one or more of wireless communication channels.

19. The method of claim 18 wherein the plurality of wireless communication channels comprise a first wireless communication channel and a second wireless communication channel, wherein the first wireless communication channel is a primary channel and a second wireless communication channel is a diversity channel.

20. The method of claim 18 wherein said compensating comprises:

detecting each of said same signal frequencies by each wireless communication channel to produce first detected energy levels; and

modifying a plurality of second detected energy levels of the plurality of signal frequencies received in the wireless communication channels based on differences between the first detected energy levels.

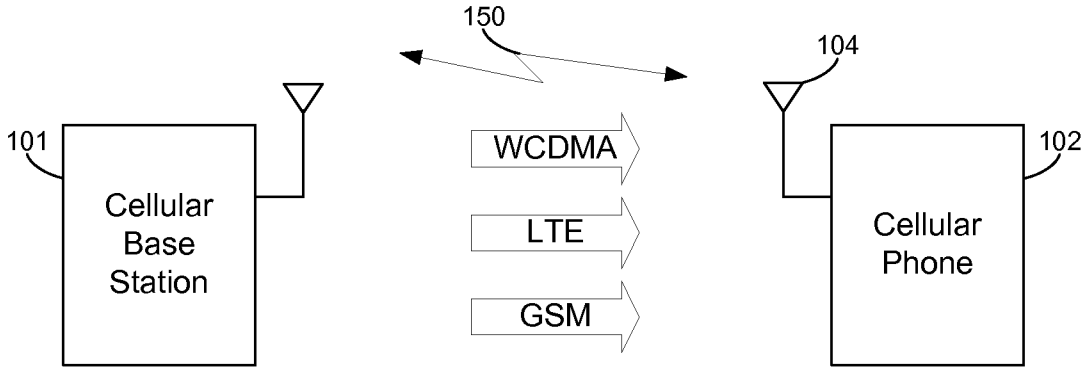
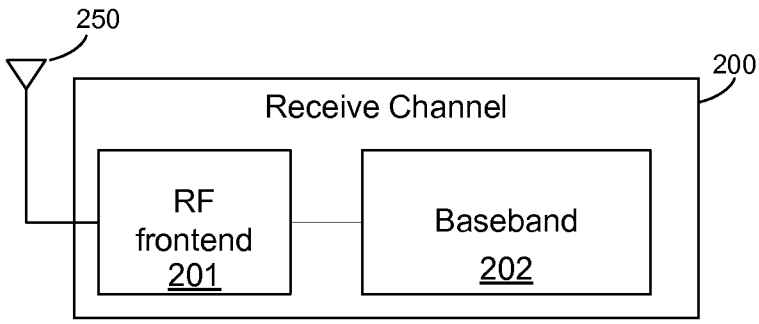


Fig. 1
(Prior Art)



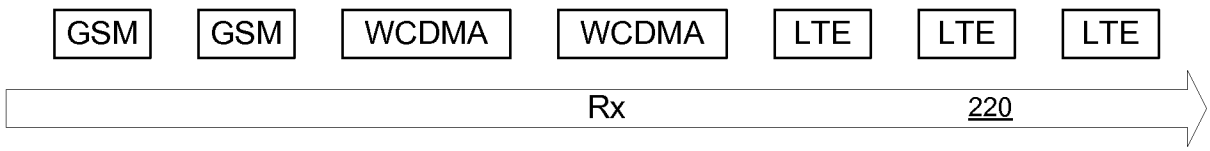


Fig. 2
(Prior Art)

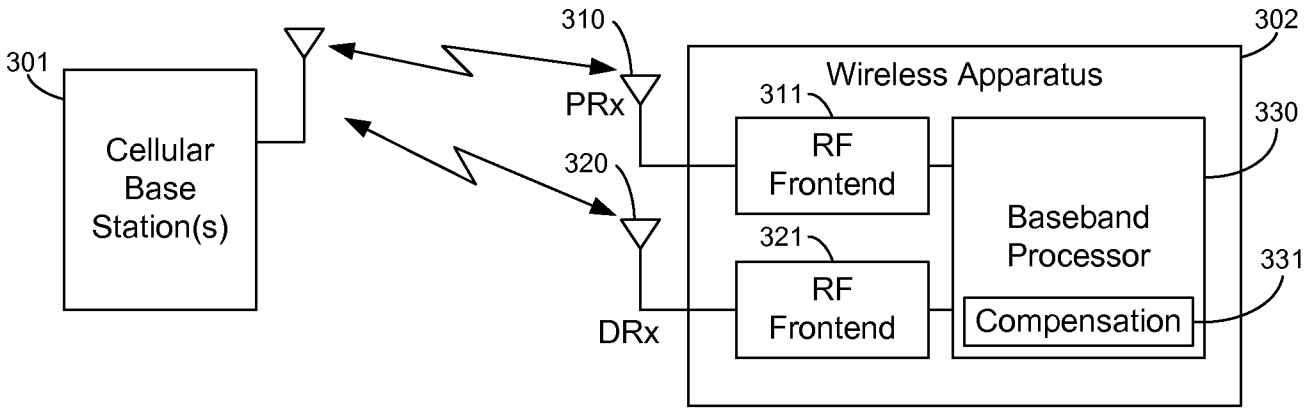

301
Cellular Base Station(s)
310
PRx
320
DRx
302
Wireless Apparatus
311
RF Frontend
321
RF Frontend
330
Baseband Processor
Compensation
331

Fig. 3

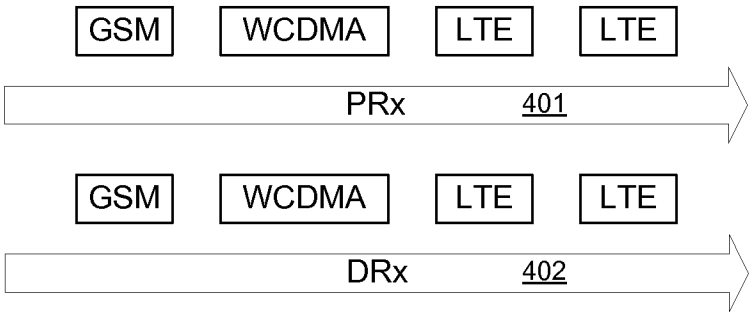

GSM
WCDMA
LTE
LTE
PRx
401
GSM
WCDMA
LTE
LTE
DRx
402

Fig. 4

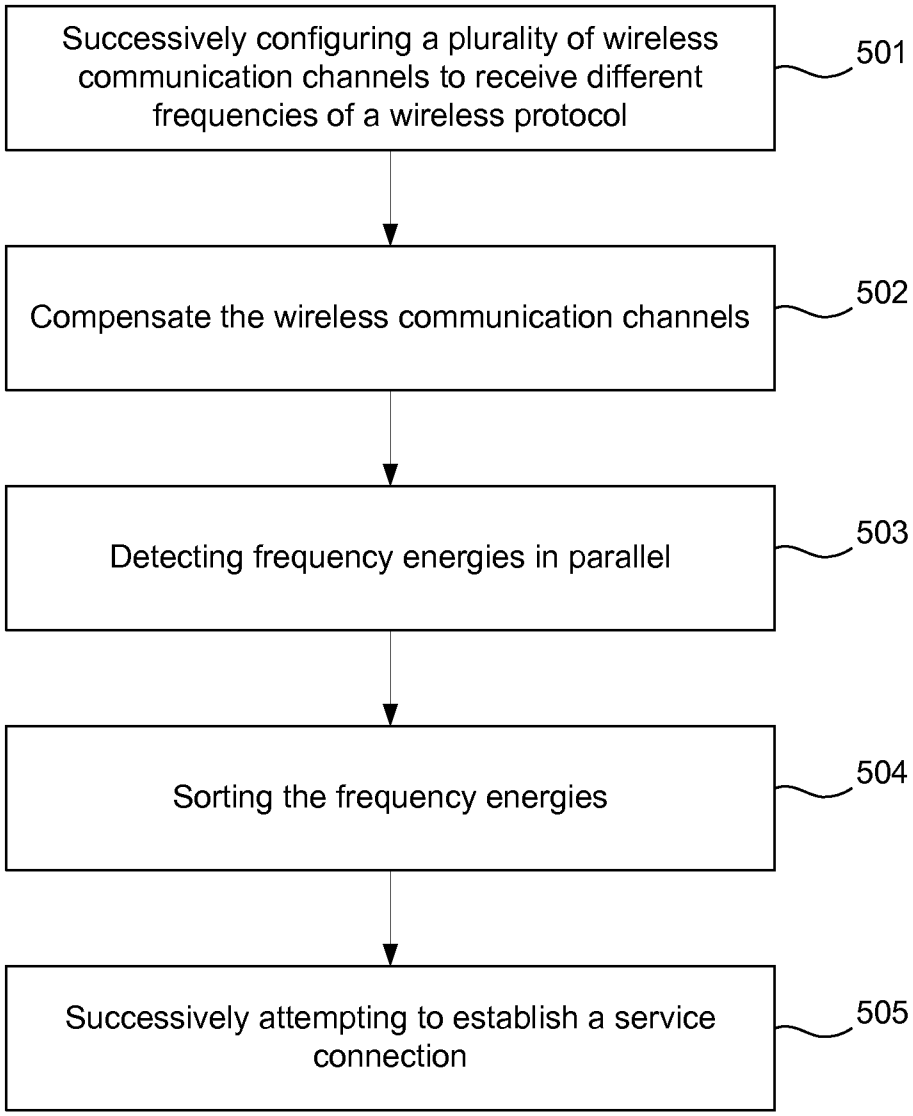

Successively configuring a plurality of wireless communication channels to receive different frequencies of a wireless protocol
501
Compensate the wireless communication channels
502
Detecting frequency energies in parallel
503
Sorting the frequency energies
504
Successively attempting to establish a service connection
505

Fig. 5

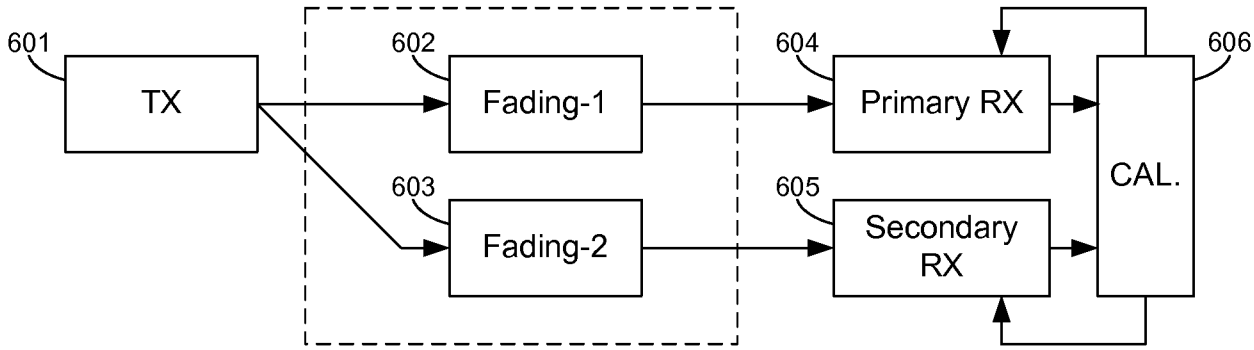
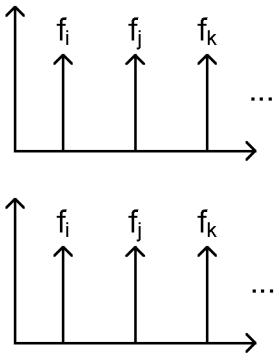
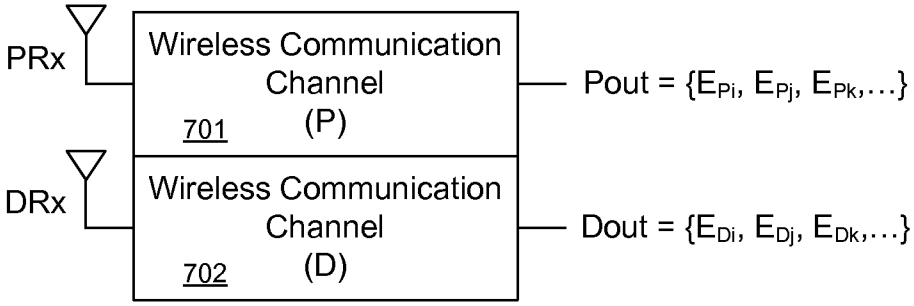


Fig. 6

700A

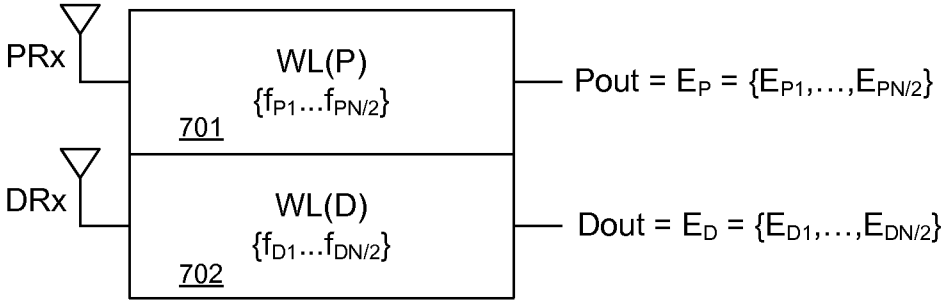
$B1 = \{f_1 \ldots f_i \ldots f_j \ldots f_k \ldots f_N\}$





700B

$B1 = \{f_1 \ldots f_i \ldots f_j \ldots f_k \ldots f_N\}$



$E_{Df} = \alpha E_{Di}$

Fig. 7

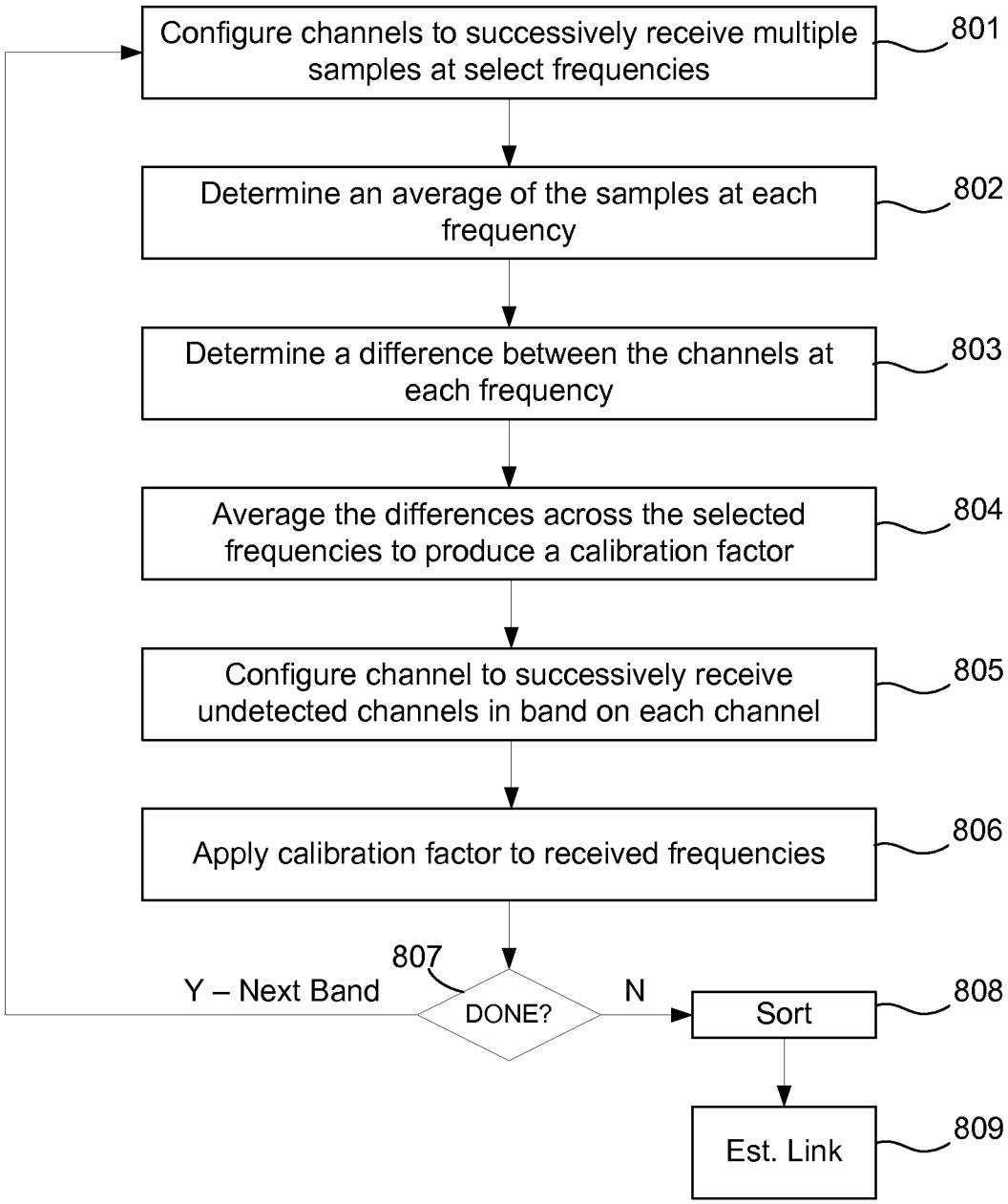

Configure channels to successively receive multiple samples at select frequencies
801
Determine an average of the samples at each frequency
802
Determine a difference between the channels at each frequency
803
Average the differences across the selected frequencies to produce a calibration factor
804
Configure channel to successively receive undetected channels in band on each channel
805
Apply calibration factor to received frequencies
806
807
DONE?
Y – Next Band
N
Sort
808
Est. Link
809

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/062868

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W48/16
ADD. H04W48/18 H04W88/06

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 H04B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, COMPENDEX, INSPEC, 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 Y	US 2008/287082 A1 (GOVINDSWAMY ARUMUGAM [US] ET AL) 20 November 2008 (2008-11-20) paragraph [0005] - paragraph [0007] paragraph [0009] - paragraph [0010] paragraph [0048] - paragraph [0050] paragraph [0062] paragraph [0069] - paragraph [0070] paragraph [0096] - paragraph [0097] figures 1, 2, 5, 7, 10	1-3,6, 10-13,16 4,5,7-9, 14,15, 17-20
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

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"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
12 March 2015	19/03/2015

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

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/062868

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 6 226 507 B1 (RAMESH RAJARAM [US] ET AL) 1 May 2001 (2001-05-01) column 4, line 14 - line 16 column 5, line 24 - line 35 column 6, line 13 - line 17 figures 1,3	4,5,7,8, 14,15, 17-20
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PCT/US2014/062868

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