FIGS. 5A and 5B illustrate a MIMO wireless communication system according to the present invention. As shown in FIG. 5A, a base station B uses adaptive antenna arrays and spatial processing to transmit distinct downlink signals x_1, x_2, x_3 through separate spatial subchannels to a subscriber unit S which uses an adaptive array and spatial processing to receive the separate signals. In a similar manner, the subscriber S uses an adaptive array to transmit distinct uplink signals x'_1, x'_2, x'_3 to the base B over the same spatial subchannels. As the multipath in the environment increases, the channel acquires a richer spatial structure that allows more subchannels to be used for increased capacity.

It is important to note that the simple assignment of the distinct signals to the distinct spatial paths in a one-to-one correspondence, as illustrated above, is only one possible way to exploit the additional capacity provided by the spatial subchannel structure. For example, coding techniques can be used to mix the signal information among the various paths. In addition, the present inventors have developed techniques for coupling these additional spatial dimensions to available temporal and/or frequency dimensions prior to transmission. Although such coupled spatio-temporal coding techniques are more subtle than direct spatial coding alone, they provide better system performance, as will be described in detail below.

In order to facilitate an understanding of the present invention and enable those skilled in the art to practice it, the following description includes a teaching of the general principles of the invention, as well as implementation details. First we develop a compact model for understanding frequency dispersive, spatially selective wireless MIMO channels. We then discuss their theoretical information capacity limits, and propose spatio-temporal coding structures that asymptotically achieve theoretical channel capacity. In particular, a spatio-temporal vector coding (STVC) structure

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for burst transmission is disclosed, as well as a more practical, reduced complexity, discrete matrix multitone (DMMT) space-frequency coding structure. Both STVC and DMMT are shown to achieve the theoretical channel capacity as the burst duration increases.

In its preferred implementations, the present invention makes use of many techniques and devices well known in the art of adaptive antenna arrays systems and associated digital beamforming signal processing. These techniques and devices are described in detail in U.S. Pat. No. 5,471,647 and U.S. Pat. No. 5,634,199, both to Gerlach et al., and U.S. Pat. No. 5,592,490 to Barratt et al., which are all incorporated herein by reference. In addition, a comprehensive treatment of the present state of the art is given by John Livita and Titus Kwok-Yeung Lo in *Digital Beamforming in Wireless Communications* (Artech House Publishers, 1996). Accordingly, the following detailed description focuses upon the specific signal processing techniques which are required to enable those skilled in the art to practice the present invention.

Consider a communication channel for a system with M_T transmitting antennas at a base B and M_R receiving antennas at a subscriber S, as illustrated in FIGS. 6A and 6B. The channel input at a sample time k can be represented by an M_T dimensional column vector

$$\mathbf{z}(k) = [z_1(k), \ldots, z_{M_T}(k)]^T,$$

and the channel output and noise for sample k can be represented, respectively, by M_R dimensional column vectors

$$\mathbf{x}(k) = [x_1(k), \ldots, x_{M_R}(k)]^T,$$

and

$$\mathbf{n}(k) = [n_1(k), \ldots, n_{M_R}(k)]^T.$$

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The communication over the channel **H** may then be expressed as a vector equation

$$\mathbf{x}(k) = \mathbf{H}\mathbf{z}(k) + \mathbf{n}(k),$$

where the MIMO channel matrix is

$$\mathbf{H} = \begin{pmatrix} h_{1,1} \cdots h_{1,M_T} \\ \vdots \quad\quad \vdots \\ h_{M_R,1} \cdots h_{M_R,M_T} \end{pmatrix}.$$

Each matrix element h_{ij} represents the SISO channel between the ith receiver antenna and the jth transmitter antenna. Due to the multipath structure of the spatial channel, orthogonal spatial subchannels can be determined by calculating the independent modes (e.g. eigenvectors) of the channel matrix **H**. These spatial subchannels can then be used to transmit independent signals and increase the capacity of the communication link between the base B and the subscriber S. Because the multipath introduces time delays, however, a spatial decomposition alone will result in temporal mixing of the signals. It is more appropriate, therefore, to perform a more general spatio-temporal analysis of the channel.

Let $\{z_j(n)\}$ be a digital symbol sequence to be transmitted from the jth antenna element, $g(t)$ a pulse shaping function impulse response, and T the symbol period. Then the signal applied to the jth antenna element at time t is given by

$$s_j(t) = \sum_n z_j(n)g(t-nT)$$

The pulse shaping function is typically the convolution of two separate filters, one at the transmitter and one at the receiver. The optimum receiver filter is a matched filter. In practice, the pulse shape is windowed resulting in a finite duration impulse response. We assume synchronous complex baseband sampling with symbol period T. We define n_0 and $(v+1)$

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to be the maximum lag and length over all paths l for the windowed pulse function sequences $\{g(nT-\tau_l)\}$. To simplify notation, it is assumed that $n_0 = 0$, and the discrete-time notation $g(nT-\tau_l) = g_l(n)$ is adopted.

When a block of N data symbols are transmitted, N+ν non-zero output samples result beginning at time sample k-N+1 and ending with sample k+ν. The composite channel output can now be written as an M_Rℵ(N+ν) dimensional column vector with all time samples for a given receive antenna appearing in order so that

$$\mathbf{x}(k) = [x_1(k-N+1),\ldots,x_1(k+\nu),\ldots,x_{M_R}(k-N+1),\ldots,x_{M_R}(k+\nu)]^T,$$

with an identical stacking for the output noise samples $\mathbf{n}(k)$. Similarly, the channel input is an M_TℵN dimensional column vector written as

$$\mathbf{z}(k) = [z_1(k-N+1),\ldots,z_1(k),\ldots,z_{M_T}(k-N+1),\ldots,z_{M_T}(k)]^T,$$

The spatio-temporal communication over the channel $\mathbf{H}$ may then be expressed as a vector equation

$$\mathbf{x}(k) = \mathbf{H}\mathbf{z}(k) + \mathbf{n}(k),$$

where the MIMO channel matrix

$$\mathbf{H} = \begin{pmatrix} \mathbf{H}_{1,1} \ldots \mathbf{H}_{1,M_T} \\ \vdots \qquad\quad \vdots \\ \mathbf{H}_{M_R,1} \ldots \mathbf{H}_{M_R,M_T} \end{pmatrix}$$

is composed of SISO sub-blocks $\mathbf{H}_{ij}$ with each sub-block possessing the well known Toeplitz form.

We will now discuss the information capacity for the spatio-temporal channel developed above. The following analysis assumes that the noise $\mathbf{n}(k)$ is additive white Gaussian noise (AWGN) with covariance $\sigma^2\mathbf{I}$. Each channel use consists of an N

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symbol burst transmission and the total average power radiated from all antennas and all time samples is constrained to less than a constant.

Write the singular value decomposition (SVD) of the channel matrix as $\mathbf{H}=\mathbf{V}_H\Lambda_H\mathbf{U}_H^*$, with the jth singular value denoted $\lambda_{H,j}$. Write the spatio-temporal covariance matrix for $\mathbf{z}(k)$ as $\mathbf{R}_z$ with eigenvalue decomposition $\mathbf{R}_z=\mathbf{V}_Z\Lambda_Z\mathbf{U}_Z^*$, and eigenvalues $\lambda_{Z,j}$.

It can be demonstrated that the information capacity for the discrete-time spatio-temporal communication channel defined above is given by

$$C = \sum_{n=1}^{N\aleph M_T} \log \left(1 + \frac{\lambda_{Z,n}|\lambda_{H,n}|^2}{\sigma^2}\right),$$

where $\lambda_{Z,n}$ is given by the spatio-temporal water-filling solution. Motivated by this result, the inventors devised the following temporal vector coding technique. By appropriately selecting up to $N\aleph M_T$ spatio-temporal transmission vectors that are multiples of the right singular vectors of $\mathbf{H}$, and receiving with up to $N\aleph M_T$ matched spatio-temporal filter vectors that are the left singular vectors of $\mathbf{H}$, up to $N\aleph M_T$ parallel spatio-temporal subchannels are constructed for communicating information over the channel. Mathematically, this STVC channel is derived as follows. Substituting $\mathbf{H}=\mathbf{V}_H\Lambda_H\mathbf{U}_H^*$ into the original equation $\mathbf{x}(k)=\mathbf{H}\mathbf{z}(k)+\mathbf{n}(k)$ for the channel gives

$$\mathbf{x}(k) = \mathbf{V}_H\Lambda_H\mathbf{U}_H^*\mathbf{z}(k) + \mathbf{n}(k),$$

Left multiplication by $\mathbf{V}_H^*$ yields

$$\mathbf{V}_H^*\mathbf{x}(k) = \Lambda_H\mathbf{U}_H^*\mathbf{z}(k) + \mathbf{V}_H^*\mathbf{n}(k),$$

which yields the STVC channel when rewritten as

$$\hat{\mathbf{x}}(k) = \Lambda_H \hat{\mathbf{z}}(k) + \hat{\mathbf{n}}(k),$$

where $\hat{\mathbf{z}}(k)=\mathbf{U}_H^* \mathbf{z}(k)$, $\hat{\mathbf{x}}(k)=\mathbf{V}_H^* \mathbf{x}(k)$ and $\hat{\mathbf{n}}(k)=\mathbf{V}_H^* \mathbf{n}(k)$.

By analyzing the ranks of the above matrices, it can be demonstrated that the maximum number of finite amplitude parallel spatio-temporal channel dimensions, K, that can be created to communicate over the far field channel defined above is equal to min { N×L, (N+v)×M_R, N×M_T }, where L is the number of multipath components. Thus, multipath is an advantage in far-field MIMO channels. If the multipath is large (L 1), the capacity can be multiplied by adding antennas to both sides of the radio link. This capacity improvement occurs with no penalty in average radiated power or frequency bandwidth because the number of parallel channel dimensions is increased. In practice, an adaptive antenna array base station, such as that described by Barratt et al., is modified to implement the above vector coding scheme. In particular, a signal processor is designed to perform a spatio-temporal transform of information signals in accordance with the above equations so that they may be transmitted through the independent parallel subchannels and decoded by the subscriber.

The space-time vector coding solution described above requires a computation of the singular value decomposition of an (N+v)×M_R × N×M_T matrix. Since this computation can be complex, the present inventors have developed an optimal space-time communication structure that requires less computational complexity to implement. In particular, complexity can be reduced by using a coding structure similar to the discrete multi-tone (DMT) standard. DMT is in widespread use for wired SISO channels. DMT has also been applied to wired MISO channels, as described in U.S. Pat. No. 5,625,651 which is hereby incorporated by reference. The present inventors have generalized DMT to the MIMO case and

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adapted it to wireless channels to obtain a novel space-frequency coding structure that results in a matrix of transmission and reception vector solutions for each discrete Fourier transform (DFT) frequency index. Because this new coding scheme has been generalized to MIMO channels characterized by a channel matrix, it is called discrete matrix multi-tone (DMMT).

In DMMT, N data symbols are again transmitted during each channel usage. However, a cyclic prefix is added to the data so that the last ν data symbols are transmitted from each antenna element prior to transmitting the full block of N symbols. By receiving only N time samples at the output of each antenna element, ignoring the first and last ν output samples, the MIMO channel submatrices $\hat{\mathbf{H}}_{ij}$ now appear as cyclic structures:

$$\hat{\mathbf{H}}_{i,j} = \begin{pmatrix} h(\nu) & \dots & h(0) & 0 & 0 & \dots & 0 & 0 & 0 & 0 \\ 0 & h(\nu) & & h(0) & 0 & \dots & 0 & 0 & 0 & 0 \\ \vdots & & & & \vdots & & \vdots & & & \vdots \\ 0 & & & & 0 & \dots & 0 & & & 0 \\ 0 & \dots & 0 & 0 & 0 & \dots & 0 & h(\nu) & \dots & h(0) \\ & & & \vdots & \vdots & & \vdots & & & \vdots \\ h(\nu-1) & \dots & h(0) & 0 & 0 & \dots & 0 & \dots & 0 & h(\nu) \end{pmatrix}$$

Given the cyclic SISO channel blocks, the channel matrix can be diagonalized with a relatively simple three step procedure. First post multiply $\hat{\mathbf{H}}$ with the $N\aleph M_T \times N\aleph M_T$ block diagonal inverse discrete Fourier transform (IDFT) matrix $\mathbf{F}^{*(M_T)}$ where each diagonal block is the unitary $N \times N$ IDFT matrix $\mathbf{F}^*$. The next step is to premultiply $\hat{\mathbf{H}}$ by a similar $N\aleph M_R \times N\aleph M_R$ block diagonal DFT matrix $\mathbf{F}^{(M_R)}$ where the diagonal submatrices $\mathbf{F}$ are $N \times N$ DFT matrices. With the well known result that the discrete Fourier transform basis vectors form the orthonormal singular vectors of the cyclic matrices $\hat{\mathbf{H}}_{ij}$, the new channel

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matrix resulting from the IDFT post multiplication and the DFT premultiplication is

$$\mathbf{F}^{(M_R)}\hat{\mathbf{H}}\mathbf{F}^{*(M_T)} = \begin{pmatrix} \Gamma_{1,1} \cdots \Gamma_{1,M_T} \\ \vdots \quad\quad \vdots \\ \Gamma_{M_R,1} \cdots \Gamma_{M_R,M_T} \end{pmatrix}$$

where $\Gamma_{i,j}$ is the diagonal matrix containing the singular values $\gamma_{i,j,n}$ of the cyclic channel submatrix $\hat{\mathbf{H}}_{ij}$. Premultiplication and postmultiplication by a permutation matrix $\mathbf{P}$ yields the block diagonal matrix

$$\mathbf{P}\mathbf{F}^{(M_R)}\hat{\mathbf{H}}\mathbf{F}^{*(M_T)}\mathbf{P} = \begin{pmatrix} \mathbf{B}_1 & & 0 \\ & \ddots & \\ 0 & & \mathbf{B}_N \end{pmatrix}$$

where

$$\mathbf{B}_n = \begin{pmatrix} \gamma_{1,1,n} \cdots \gamma_{1,M_T,n} \\ \vdots \quad\quad \vdots \\ \gamma_{M_R,1,n} \cdots \gamma_{M_R,M_T,n} \end{pmatrix}$$

is the $M_R \times M_T$ space-frequency channel evaluated at DFT index n. Given the SVD of $\mathbf{B}_n = \mathbf{V}_{B,n}\Lambda_{B,n}\mathbf{U}^*_{B,n}$, the diagonal DMMT channel matrix $\hat{\mathbf{H}}$ is finally obtained by post multiplying by $\mathbf{U}_B^{(M_T)}$ and premultiplying by $\mathbf{V}_B^{*(M_R)}$ to obtain

$$\Lambda_{\hat{H}} = \mathbf{V}_B^{*(M_R)}\mathbf{P}\mathbf{F}^{(M_R)}\hat{\mathbf{H}}\mathbf{F}^{*(M_T)}\mathbf{P}\mathbf{U}_B^{(M_T)} = \begin{pmatrix} \Lambda_{\hat{H},1} & & 0 \\ & \ddots & \\ 0 & & \Lambda_{\hat{H},N} \end{pmatrix}$$

where $\mathbf{U}_B^{(M_T)}$ is block diagonal containing the right singular matrices of the $\mathbf{B}_n$ matrices, $\mathbf{V}_B^{*(M_R)}$ is block diagonal containing the left singular matrices of the $\mathbf{B}_n$ matrices, and each of the diagonal submatrices $\Lambda_{\hat{H},n}$ contains the DMMT spatial sub-channel amplitudes, $\lambda_{\hat{H},n,j}$ for DFT bin n. The parallel channel DMMT equation is then

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$$\hat{\mathbf{x}}(k) = \Lambda_{\hat{H}}\hat{\mathbf{z}}(k) + \hat{\mathbf{n}}(k),$$

where $\mathbf{z}(k)$ is the dimension $N \aleph M_T$ input symbol vector, $\hat{\mathbf{x}}(k)$ is the dimension $N \aleph M_R$ output symbol vector, and $\hat{\mathbf{n}}(k)$ is the dimension $N \aleph M_R$ equivalent output noise vector after the DFT and spatial orthogonalization operations are performed. A block diagram architecture that implements this DMMT space-frequency channel decomposition is presented in FIG. 7. The left portion of the diagram corresponds to the application of the operators $\mathbf{F}^{*(M_T)}\mathbf{PU}_B^{(M_T)}$ on the signal $\hat{\mathbf{z}}(k)$. These operations are performed by a signal processor at the transmitter. The right portion of the diagram corresponds to the application of the operators $\mathbf{V}_B^{*(M_R)}\mathbf{PF}^{(M_R)}$ on the received signals to recover a received information signal $\hat{\mathbf{x}}(k)$. These operations are performed by a signal processor at the receiver. The central matrix $\hat{\mathbf{H}}$ corresponds to the spatial channel itself. By construction, the signal processing operations result in a direct relationship between the received and transmitted information signals, as indicated by the fact that the matrix $\Lambda_{\hat{H}}$ in the parallel channel DMMT equation is diagonal.

This coding scheme significantly reduces the signal processing complexity required at the transmitter and receiver to diagonalize all space-time subchannels for each data block. In particular, this asymptotically optimal space-frequency MIMO DMMT information transmission technique has a complexity advantage of approximately N^2 as compared to the vector coding case. Moreover, since all of the matrix operations involved in creating the diagonal DMMT channel are invertible, the capacity of the DMMT channel is unchanged from that of the original cyclic sub-block matrix $\hat{\mathbf{H}}$. Thus, compared to STVC, the only capacity decrease for the DMMT space-time coding solution is due to the radiated power penalty required to transmit the cyclic prefix. This capacity penalty, however,

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becomes small for large N. Thus, this new communications structure offers the advantage of very large increases in capacity without penalty in total average transmitted power or bandwidth.

In order to perform transmit beamforming, the base station signal processor computes spatio-temporal downlink subchannel information from downlink channel information fed back from the subscriber. The downlink signal information is then encoded in accordance with this computed downlink subchannel information. Similarly, the subscriber performs the same functions for the uplink channel using information fed back from the base. Because the present invention provides techniques for efficient channel estimation and increased channel capacity, the base and subscriber can both quickly estimate the channel and exchange channel information over the increased capacity channels, possibly at a rate slower than that of information data. As a result, both the base and subscriber can maintain a high degree of spatial resolution in transmit beamforming, thereby significantly reducing cochannel interference from other base stations or subscribers. As a result of this high degree of spatial discrimination in both transmission and reception, many more base stations and subscribers can share the same region of space while using the same frequency channel. Consequently, in addition to increasing the capacity of the channel between any two arrays, the present invention also increases system wide capacity by significantly reducing cochannel interference.

The teaching contained in this description can easily be extended to channels where the noise is not white but is highly structured as in the case of additive co-channel interference. In this case, large gains in cellular network capacity result from the ability to null interference at the receiver and the ability to constrain radiated interference power at the transmitter. These spatial coding techniques can also be applied to single frequency subchannel systems with

flat fading, conventional analog multicarrier transmission channels, or CDMA channels where each code delay can be decomposed into orthogonal subchannels provided that there is sub-chip multipath. The concepts of the present invention can also be applied to a more general class of channels where the antenna array is distributed over large distances and the propagation does not follow far field behavior. Finally, other communication media such as wire-line, acoustic media, and optical media will experience the same basic communication system benefits when spatio-temporal MIMO channel structures are employed. Thus, it will be clear to one skilled in the art that the above embodiment may be altered in many ways without departing from the scope of the invention. Accordingly, the scope of the invention should be determined by the following claims and their legal equivalents.

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CLAIMS

What is claimed is:

1. A method of digital wireless communication between a base station and a subscriber unit, the method comprising:
determining from channel information a number L of independent spatial subchannels, wherein the channel information comprises spatial information relating to a spatial channel coupling an array of M_T antenna elements at the base station with an array of M_R antenna elements at the subscriber unit;
encoding a plurality of information signals into a sequence of transmitted signal vectors, wherein the transmitted signal vectors have M_T complex valued components and are selected to send distinct information signal over the independent spatial subchannels;
transmitting the sequence of transmitted signal vectors from the array of M_T antenna elements at the base station;
receiving a sequence of received signal vectors at the array of M_R antenna elements at the subscriber unit, wherein the received signal vectors have M_R complex valued components; and
decoding the received signal vectors to recover the information signals.

2. The method of claim 1 further comprising transmitting the channel information from the subscriber to the base.

3. The method of claim 1 wherein the channel information comprises a spatio-temporal channel matrix.

4. The method of claim 1 wherein the number L of independent spatial subchannels is equal to the number of multiple signal paths between the base and the subscriber.

5. The method of claim 1 wherein the encoding step comprises scaling the information signals by complex numbers,

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permuting the scaled information signals and inverse Fourier transforming the permuted scaled information signals, and wherein the decoding step comprises Fourier transforming the received signals, permuting the Fourier transformed received signals, and scaling the permuted Fourier transformed received signals.

6. A method of digital wireless communication between a base station and a subscriber unit, the method comprising:

computing from a set of K original information signals a spatio-temporal coded signal in accordance with a channel matrix **H** having K parallel spatio-temporal subchannels;

transmitting the spatio-temporal coded signal from a base station array of M_T antenna elements through a channel corresponding to the channel matrix **H** to a subscriber unit array of M_R antenna elements; and

computing from the transmitted spatio-temporal coded signal a set of K received information signals.

7. The method of claim 6 wherein K is not more than $(N+\nu) \times M_R$, not more than $N \times M_T$, and not more than $N \times L$, where L is a maximum number of multipath components between the base station and the subscriber unit, and where $(N+\nu)$ is a maximum number of nonzero output samples transmitted for a block of N symbols.

8. The method of claim 6 wherein the original information signals comprise K blocks of N symbols, and the channel matrix **H** comprises $M_T \times M_R$ blocks of $N \times (N+\nu)$ channel matrices $\mathbf{H}_{ij}$, where $(N+\nu)$ is a maximum number of nonzero output samples transmitted for a block of N symbols.

9. The method of claim 6 wherein cyclic prefixes are added to the coded signal prior to the transmitting step, thereby facilitating the efficient computation of the K received information signals from the transmitted spatio-temporal coded signal.

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10. The method of claim 6 wherein the K parallel spatio-temporal subchannels are characterized by a set of K spatio-temporal transmission sequences that are derived from a decomposition of **H** into independent modes.

11. The method of claim 6 wherein the K parallel spatio-temporal subchannels are characterized by a set of K spatio-temporal transmission sequences that are multiples of right singular vectors of **H**, and matched set of K spatio-temporal filter sequences that are left singular vectors of **H**.

12. A digital wireless communication system comprising:

a base station comprising a base station antenna array and a base station signal processor coupled to the base station antenna array;

a subscriber unit comprising a subscriber antenna array coupled through a wireless channel to the base station antenna array and a subscriber signal processor coupled to the subscriber antenna array;

wherein the base station signal processor computes spatio-temporal downlink subchannel information from downlink channel information received from the subscriber, and encodes downlink signal information in accordance with the computed downlink subchannel information; and

wherein the subscriber signal processor computes spatio-temporal uplink subchannel information from uplink channel information received from the base station, and encodes uplink signal information in accordance with the computed uplink subchannel information.

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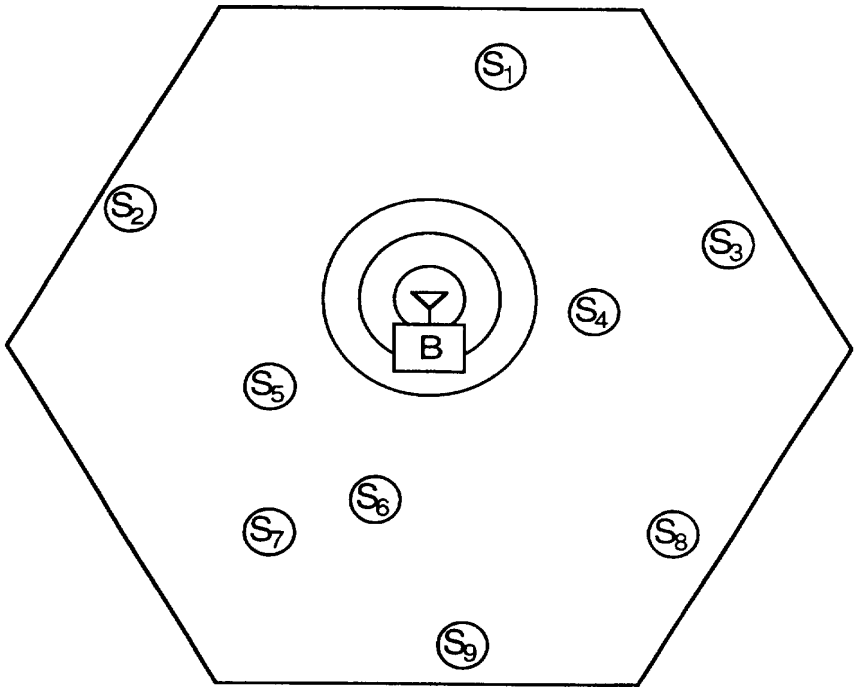

FIG. 1
(PRIOR ART)

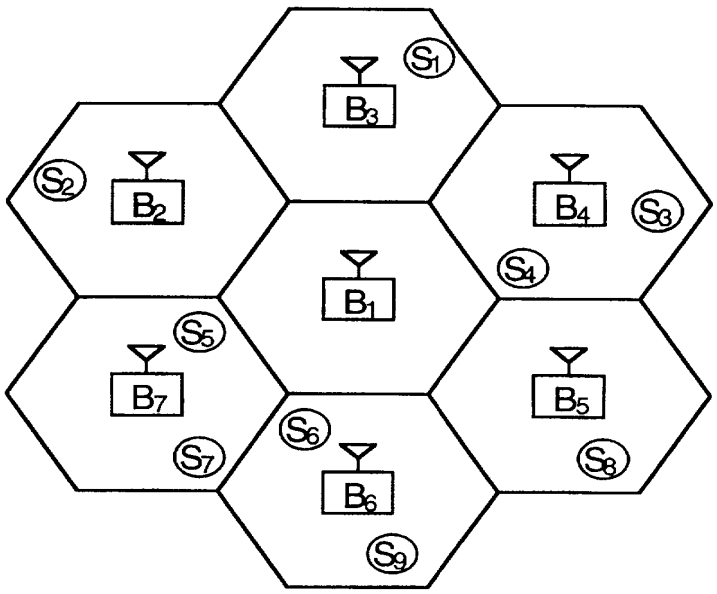

FIG. 2
(PRIOR ART)

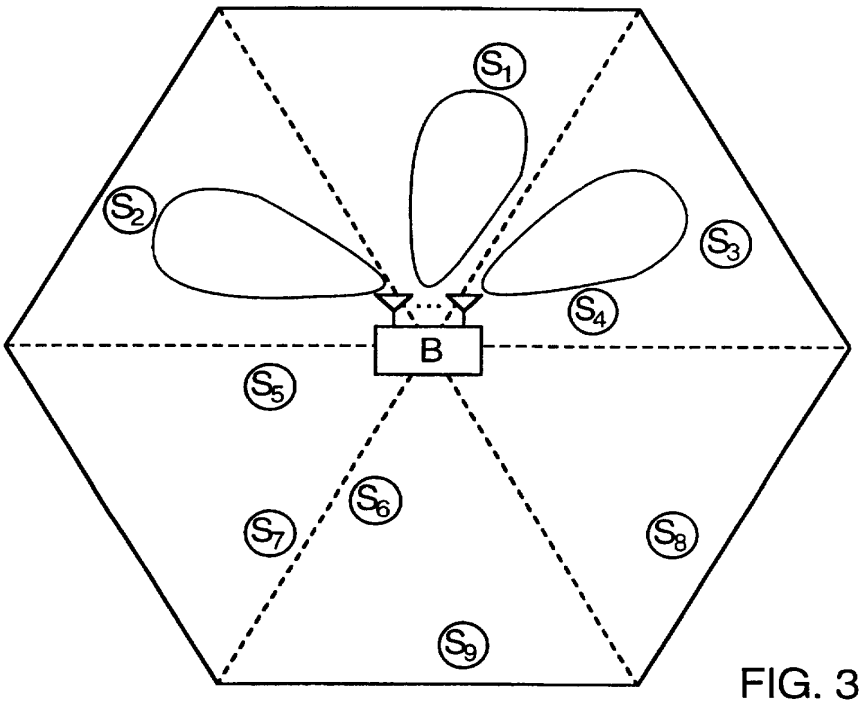

FIG. 3
(PRIOR ART)

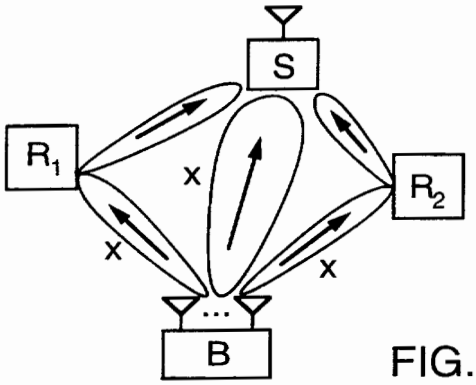

FIG. 4A
(PRIOR ART)

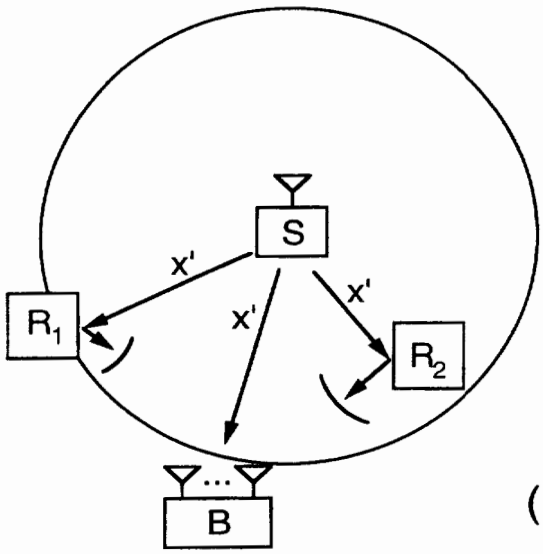

FIG. 4B
(PRIOR ART)

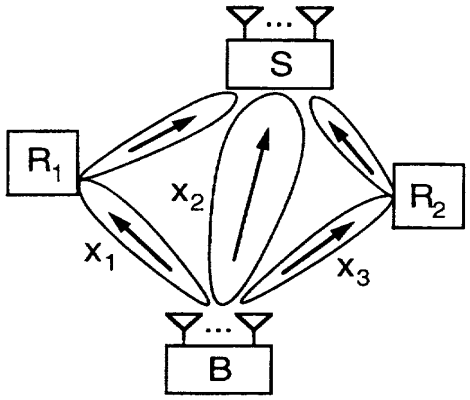

FIG. 5A

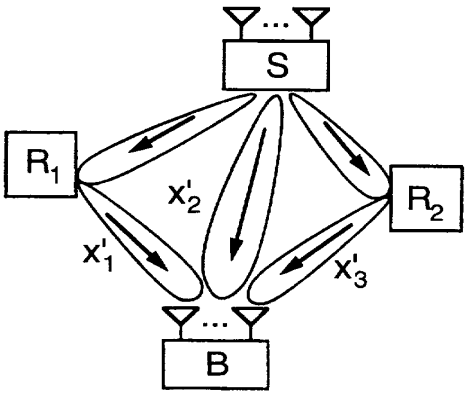

FIG. 5B

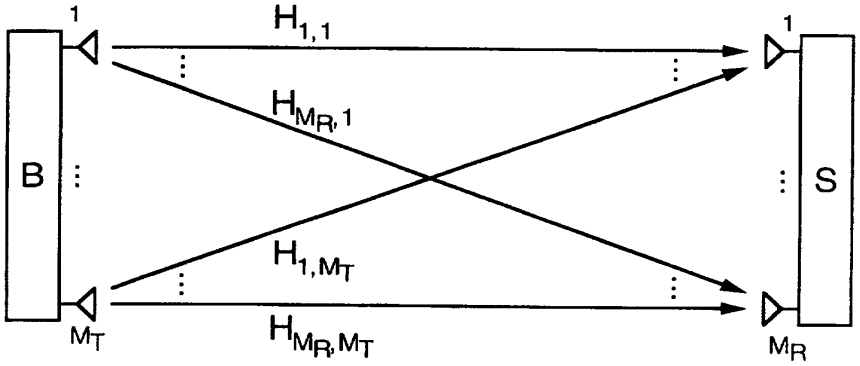
1
$H_{1,1}$
1
$H_{M_R,1}$
B
S
H_{1,M_T}
M_T
H_{M_R,M_T}
M_R

FIG. 6A

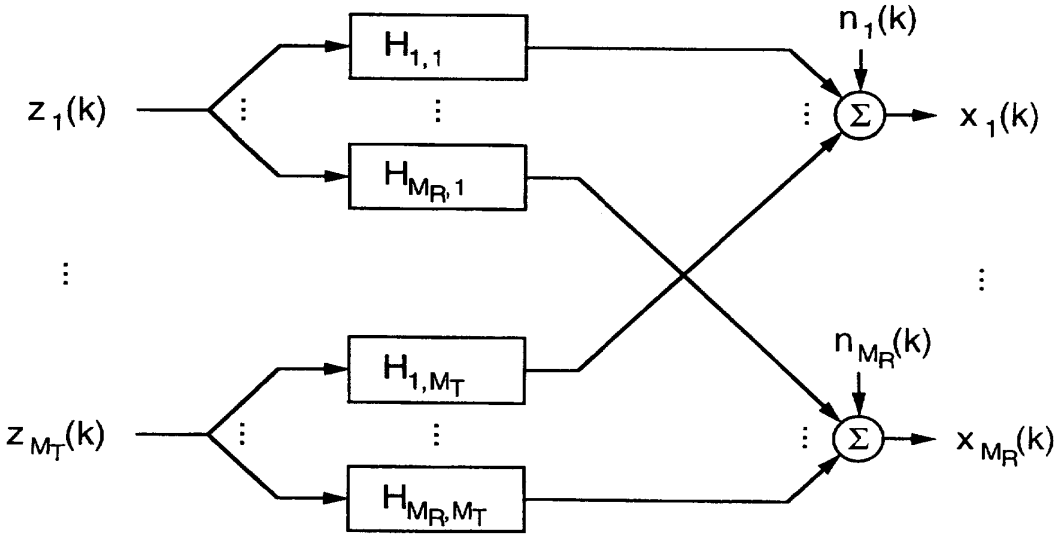
$n_1(k)$
$H_{1,1}$
$z_1(k)$
Σ
$x_1(k)$
$H_{M_R,1}$
$n_{M_R}(k)$
H_{1,M_T}
$z_{M_T}(k)$
Σ
$x_{M_R}(k)$
H_{M_R,M_T}

FIG. 6B

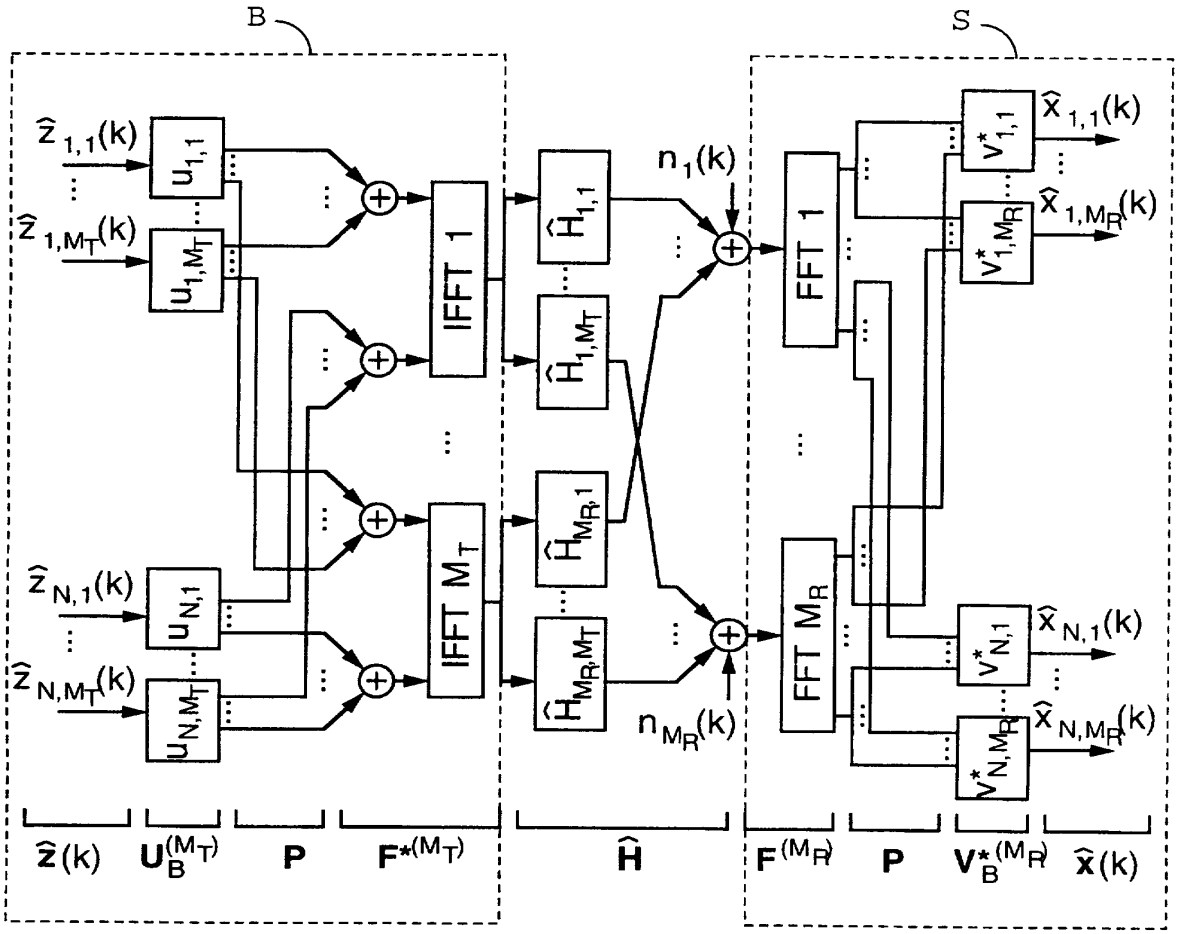
B
S
IFFT 1
IFFT M_T
FFT 1
FFT M_R
n_1(k)
n_MR(k)
ẑ(k)
U_B^(MT)
P
F*(MT)
Ĥ
F^(MR)
P
V_B*(MR)
x̂(k)

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15363

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H04B 1/38; H04M 1/00
US CL :455/562, 101, 103, 272
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)
U.S. : 455/562, 101, 103, 272, 504, 506, 65, 132; 375/347

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,710,944 A (NOSSEN) 01 December 1987, columns 3-8, figures 1 and 5.	1-12
X	US 5,548,819 A (ROBB) 20 August 1996, columns 10-13, figures 1a-1b.	1-12
A,P	US 5,649,287 A (FORSSEN ET AL) 15 July 1997, figure 5.	1-12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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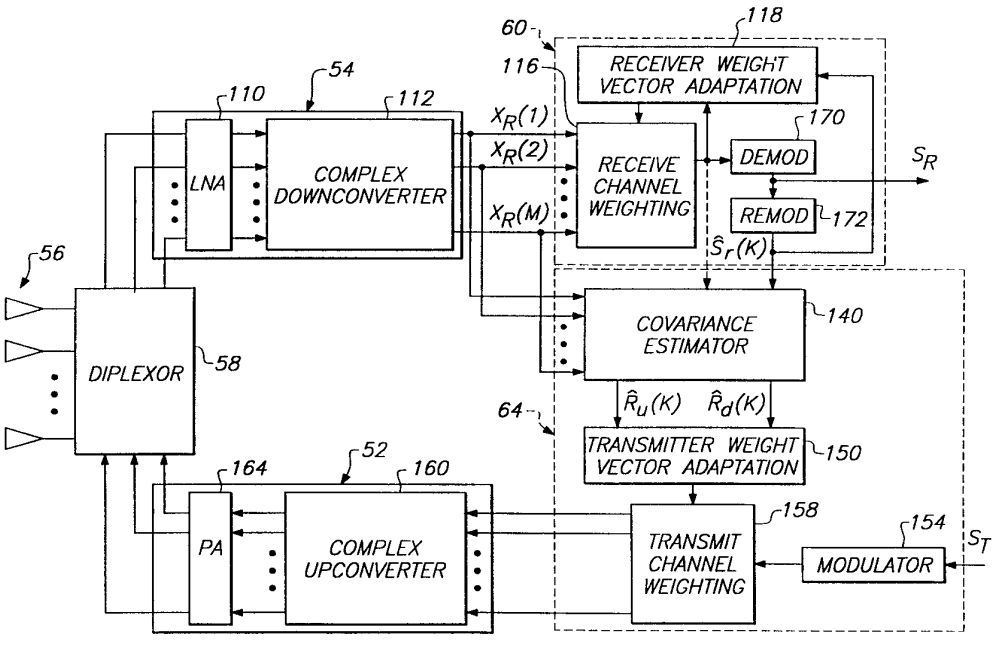
(57) Abstract

An adaptive reception and transmission technique according to one embodiment of the invention offers the advantages of adaptive reception transmission using feedback without the associated mobile radio complexity increase and information capacity penalty. The technique has been developed to exploit structured variation which occurs in the multipath fading present in the wireless antenna array channel. Thus, multipath propagation effects are explicitly accounted for in the problem approach. The technique is blind in that the antenna beam is formed in the absence of explicit knowledge of the array geometry, and without the necessity of array calibration or mobile feedback. The basic approach is to estimate to optimum receive and transmit antenna beam pattern based on certain statistical properties of the received antenna array signals. The optimum receive and transmit beam pattern is found by solving an optimization equation. The adaptive transceiver system is suitable for use in conjunction with either a diplexed transmit/receive antenna array, or with separate transmit and receive arrays.



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WIRELESS COMMUNICATION NETWORK USING TIME-VARYING VECTOR CHANNEL EQUALIZATION FOR ADAPTIVE SPATIAL EQUALIZATION

RELATED APPLICATIONS

This application claims priority to the following applications and incorporates these applications by reference:

U.S. Ser. No. 08/394,652 filed on February 22, 1995;

U.S. Ser, No. 08/491,044, filed on June 16, 1995; and

U.S. Prov. App. No. 60/005,647 filed on October 19, 1995.

FIELD

The present invention relates to a wireless communication network that uses time-varying vector channel equalization for adaptive spatial equalization. In particular, the invention is used in a wireless communication network to improve the quality of communication.

BACKGROUND

Within wireless mobile communication systems, procedures for compensating for multipath effects are desirable. Unlike "line-of-sight" radio links, a number of signal transmission paths typically comprise each wireless communication channel, hence the term "multipath." An increase in primary path communication energy is desired with an attendant reduction in the interference energy radiated to mobile users over other non-primary paths. Often this increase in primary path

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communication energy is achieved through generation of spatially selective, directive transmission beam patterns.

Some systems employ directive antennas at base station sites to increase the signal level received from and transmitted to each mobile user relative. Other systems use an antenna array that is used to form beams to increase the signal level received from and transmitted to each mobile user. In the systems with an antenna array, often called a phased array, weights are used to account for various angles that the beam will provide. Problems occur when severe multipath signals are created by a plurality of obstructions such as buildings and mountains. When severe multipath occurs, many systems suffer severe quality degradation. Known systems cannot sufficiently account for severe multipath and the result is reduced quality communication.

Figure 1 shows an illustrative representation of a wireless "multipath" communication channel between a base station 2 and a remote mobile user 4. The various signal transmission paths within each such multipath communication channel arise from reflection of the transmitted signal by dominant reflection surfaces 6, and by minor reflection surfaces 12, between the base station 2 and remote mobile user 4. Accordingly, techniques for improving signal reception in line-of-sight radio systems are often not directly applicable to multipath signal environments. For example, in line-of-sight system the "gain" of an antenna typically varies inversely to antenna beam width. However, if a given antenna beam width is made less than the angular region encompassing the various signal paths comprising a multipath communication channel, further reduction in the beam width may reduce the energy radiated along some of the angular paths. In turn, this may actually decrease the effective time average gain of the antenna.

These systems that perform blind transmission fail to employ a sufficient method for determining the received angle of the mobile station signal. As a result, known transmission beamforming techniques often use a trial and error approach that works barely satisfactorily, and does not always provide high quality communication.

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RELATED ART

Within wireless mobile communication systems, three techniques have been developed for improving communication link performance using directive transmit antennas: (i) selection of a particular fixed beam from an available set of fixed beams, (ii) adaptive beam forming based on receive signal angle estimates, (iii) adaptive transmission based on feedback provided by the remote mobile user, and (iv) adaptive transmit beam forming based upon the instantaneous receive beam pattern. Each of these techniques is described briefly below.

In the first technique, one of several fixed base station antenna beam patterns is selected to provide a fixed beam steered in a particular direction. The fixed antenna beams are often of equal beam width, and are often uniformly offset in boresight angle so as to encompass all desired transmission angles. The antenna beam selected for transmission typically corresponds to the beam pattern through which the largest signal is received. The fixed beam approach offers the advantage of simple implementation, but provides no mechanism for reducing the signal interference power radiated to remote mobile users within the transmission beam of the base station. This arises because of the inability of the traditional fixed beam approach to sense the interference power delivered to undesired users.

The second approach involves "adapting" the beam pattern produced by a base station phase array in response to changing multipath conditions. In such beamforming antenna arrays, or "beamformers", the antenna beam pattern is generated so as to maximize signal energy transmitted to ("transmit beamforming"), and received from ("receive beamforming"), an intended recipient mobile user.

While the process of transmit beamforming to a fixed location over a line-of-sight radio channel may be performed with relative ease, the task of transmitting to a mobile user over a time-varying multipath communication channel is typically considerably more difficult. One adaptive transmit beamforming approach contemplates determining each angle of departure (AOD) at which energy is to be transmitted from the base station antenna array to a given remote mobile user. Each AOD corresponds to one of the signal paths of the multipath channel, and is determined by estimating each angle of arrival (AOA) at the base station of signal energy from the given user. A transmit beam pattern is then adaptively

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formed so as to maximize the radiation projected along each desired AOD (i.e, the AOD spectrum), while minimizing the radiation projected at all other angles. Several well known algorithms (e.g., MUSIC, ESPRIT, and WSF) may be used to estimate an AOA spectrum corresponding to a desired AOD spectrum.

Unfortunately, obtaining accurate estimates of the AOA spectrum for communications channels comprised of numerous multipath constituents has proven problematic. Resolving the AOA spectrum for multiple co-channel mobile units is further complicated if the average signal energy received at the base station from any of the mobile units is significantly less than the energy received from other mobile units. This is due to the fact that the components of the base station array response vector contributed by the lower-energy incident signals are comparatively small, thus making it difficult to ascertain the AOA spectrum corresponding to those mobile units. Moreover, near field obstructions proximate base station antenna arrays tend to corrupt the array calibration process, thereby decreasing the accuracy of the estimated AOA spectrum.

In the third technique mentioned above, feedback information is received at the base station from both the desired mobile user, and from mobile users to which it is desired to minimize transmission power. This feedback permits the base station to "learn" the "optimum" transmit beam pattern, i.e., the beam pattern which maximizes transmission to the desired mobile user and minimizes transmission to all other users. One disadvantage of the feedback approach is that the mobile radio needs to be significantly more complex than would otherwise be required. Moreover, the information carrying capacity of each radio channel is reduced as a consequence of the bandwidth allocated for transmission of antenna training signals and mobile user feedback information. The resultant capacity reduction may be significant when the remote mobile users move at a high average velocity, as is the case in most cellular telephone systems.

The fourth conventional technique for improving communication link performance involves use of an optimum receive beam pattern as the preferred transmission beam pattern. After calibrating for differences between the antenna array and electronics used in the transmitter and receiver, it is assumed that the instantaneous estimate of the nature of the receive channel is equivalent to that of the

transmit channel. Unfortunately, multipath propagation and other transient channel phenomenon can substantially eliminate any significant equivalence between frequency-duplexed transmit and receive channels, or between time-division duplexed transmit and receive channels separated by a significant time interval. As a consequence, communication link performance fails to be improved.

SUMMARY

The present invention relates to a wireless communication network that uses time-varying vector channel equalization for adaptive spatial equalization. In particular, the invention is used in a wireless communication network to improve the quality of communication.

Accordingly, it is an object of the invention to provide an adaptive receive and transmit beamforming technique that improves communication quality by utilizing the received signal energy from remote users.

It is another object of the invention to provide an adaptive receive and transmit beamforming technique which accounts for the presence of multipath fading inherent in the communication channel.

It is yet another object of the invention that the beamforming technique be independent of antenna array geometry, array calibration, or of explicit feedback control signals from remote users.

It is another object of the invention to provide adaptive receive and transmit beam forming that improves signal quality received by a desired user and while simultaneously reducing interference energy received by other undesired users so as to, within a cellular communication network, improve communication traffic capacity, and/or to increase base station coverage area, and/or to improve call quality.

An adaptive reception and transmission technique according to one embodiment of the invention offers the advantages of adaptive reception transmission using feedback without the associated mobile radio complexity increase and information capacity penalty. The technique has been developed to exploit structured variation which occurs in the multipath fading present in the wireless antenna array channel. Thus, multipath propagation effects are explicitly accounted

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for in the problem approach. The technique is blind in that the antenna beam is formed in the absence of explicit knowledge of the array geometry, and without the necessity of array calibration or mobile feedback. The basic approach is to estimate the optimum receive and transmit antenna beam pattern based on certain statistical properties of the received antenna array signals. The optimum receive and transmit beam pattern is found by solving an optimization equation. The adaptive transceiver system is suitable for use in conjunction with either a diplexed transmit/receive antenna array, or with separate transmit and receive arrays.

Advantages of the invention include reduced interference and improved communication quality.

BRIEF DESCRIPTION OF THE FIGURES

Additional advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings, in which:

Figure 1 is an illustrative representation of a multipath propagation channel between a base station and a remote user station;

Figure 2A is a block diagram of the physical implementation of a beamforming network configured to perform adaptive beam forming in accordance with the present invention;

Figure 2B is a block diagram of the physical implementation of a beamforming network in which a diplexor is employed to allow the antenna array to be used for both transmit and receive operation;

Figure 3 is a functional block diagrammatic representation of a beamforming network of the present invention;

Figure 4 is a graph depicting estimated signal SINR versus adaptation time for signal 1;

Figure 5 is a graph depicting estimated signal SINR versus adaptation time for signal 2;

Figure 6 is a graph depicting estimated signal SINR versus adaptation time for signal 3; and

Figure 7 is a graph showing theoretical performance bounds for variable λ.

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DETAILED DESCRIPTION

The present invention relates to a wireless communication network that uses time-varying vector channel equalization for adaptive spatial equalization. In particular, the invention is used in a wireless communication network to improve the quality of communication.

The exemplary embodiments are described herein with reference to specific configurations and protocols. Those skilled in the art will appreciate that various changes and modifications can be made to the exemplary embodiments while remaining within the scope of the present invention.

The problem we consider is blind adaptive spatial equalization with a multiple antenna base station array for the purpose of increasing reverse link spectral efficiency (Erlangs/Hz/base station) or range by canceling interference and enhancing the desired signal over noise. In blind equalization, the equalizer weight vector adaptation relies on the structure of the transmitted signal rather than a known training signal. While these techniques may be applied at the portable unit, this present embodiments focus on spatial equalization at the base station.

The communication channel formed between a portable wireless user and a wireless base station varies with time. When the portable moves with high velocity, the time variation in the channel can become severe. Over the past decade, a large body of work has been devoted to blind spatial equalization in time invariant channels. However, less work has been reported for large Doppler-spread conditions. For certain communication signals, including narrow-band FM, the known existing equalizer algorithms fail to converge in rapidly fading environments. This occurs because the channel changes significantly over the time interval required to determine the next equalizer weight vector update.

In most conventional adaptive algorithms, the signal quality criteria is minimum mean squared error (MMSE). We will show that this criteria may not be the best choice in rapidly fading channels. We will also show that the signal to interference plus noise ratio (SINR) criteria can be more robust in rapidly fading channels. With this information and motivation, an algorithm is developed which adaptively optimizes an interesting variation of the conventional SINR criteria.

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The exemplary equalizer decomposes the received vector signal into a desired signal subspace and an interference plus noise subspace. In order to accurately estimate these two subspaces, we exploit the inherent time correlation structure that exists in the fading channel to obtain instantaneous blind estimates of the desired channel. Supplement 1 is provided for additional information and includes additional background and introduction material.

I. Overview of Beamforming Network

Turning now to Figure 2A, a block diagram is shown of the physical organization of a beamforming network 50 configured to perform adaptive beam forming in accordance with the present invention. In an exemplary embodiment the beamforming network 50 is disposed within a base station of a cellular communications network, in which is included a transceiver comprised of a radio frequency (RF) transmitter 52 and an RF receiver 54.

In the embodiment of Figure 2A, a base station antenna array 56 serves to produce independent transmit and receive antenna beams for facilitating communication with one or more mobile units (not shown). The term "receive channel vector" is employed to indicate that each antenna element within the base station antenna array 56 will form a propagation channel to a given remote user. The composite array channel may be represented as a vector having elements corresponding to each individual antenna channel. As is described herein, statistical characterization of the receive channel vector provides information which may be used by the base station to determine an "optimal" transmit beam pattern, i.e., a transmit beam pattern which maximizes the average signal-to-interference power delivered to a given mobile user. This obviates the need for the mobile unit to provide feedback information to the base station relating to propagation characteristics of the transmit channel. This in turn simplifies implementation of the mobile unit, and preserves channel resources for data transmission by eliminating the need for "mobile unit feedback" relating channel characteristics to the base station.

As is indicated by Figure 2A, a diplexer 58 can be employed to allow the antenna array 56 to be used for both transmit and receive operation by isolating the RF receiver 54 from the RF transmitter 52. A receive channel beamformer 60

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cooperates with the RF receiver 54 to adaptively optimize the receive antenna beam in order to improve received signal quality. Similarly, a transmit channel beamformer 64 cooperates with the RF transmitter 52 to adapt the transmit antenna beam to optimize some characteristic of transmission quality. In an exemplary embodiment the transit channel beamformer 64 and receive channel beamformer 60 are each implemented as a special purpose digital signal processor (DSP).

In another embodiment of the invention, distinct antenna arrays are used for signal reception and transmission as illustrated in Figure 2B. In the embodiment of Figure 2B, a diplexer is not required since a dedicated receive antenna array (not shown) is connected to the RF receiver 54, and a dedicated transmit antenna array (not shown) is connected to the RF transmitter 52. The receive and transmit antenna arrays are designed to provide identical radiation characteristics when operated at the receive and transmit frequencies, respectively. Accordingly, in many instances the physical geometries of the transmit and receive antenna arrays are simply physically scaled to account for the fractional difference in the receive and transmit RF wavelengths. The embodiment of Figure 2B substantially eliminates the potential introduction of error arising from use of a single antenna array and diplexer.

Turning now to Figure 3, a functional block diagrammatic representation is provided of a beamforming network of the present invention. In Figure 3, solid lines are used to represent functional elements and dashed lines are employed to identify the physical components of Figure 2. The RF receiver 54 is functionally comprised of a low-noise amplifier (LNA) network 110, and a complex downconverter 112. The complex downconverter 112 is disposed to frequency downconvert the received RF signal energy after processing by the LNA network 110. The downconverted signal energy is then digitally sampled and provided to a receive channel weighting module 116 of the receive channel beamformer 60. The weights applied by the receive channel beamformer 60 to each of the M downconverted antenna element outputs $x_{R,m}(k)$, m =1 to M, of the complex frequency downconverter 112 are determined by a receiver weight vector adaptation module 118. In the exemplary embodiment the receiver weight vector adaptation module 118 determines a receive channel weight vector, $\mathbf{w}_R$, which maximizes the

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signal quality received over the desired inbound frequency channel. The weight vector calculation is performed according to that described in Supplement 1.

In the embodiment of Figure 3, a vector channel covariance estimator 140 within the transmit beamformer 64 operates to produce a statistical characterization of a receive channel vector using: (i) the outputs $x_{R,m}(k)$, m =1 to M, of the complex frequency downconverter 112, and (ii) an estimate of the desired signal $\hat{S}_r(k)$ generated in the receive channel beamformer 60. For present purposes the receive channel vector may be viewed as being representative of the multipath communications channel from a mobile user (not shown in Figure 3) to the antenna array 56. In an exemplary embodiment the statistical characterization carried out within the covariance estimator 140 yields an estimated receive channel covariance matrix used during the transmit beamforming process. Throughout the following description, scalar quantities are represented using lower case characters of standard type, vector quantities are represented using lower case characters of bold type, and matrix quantities are represented using upper case characters of bold type.

Within the transmit channel beamformer 64, an optimal transmit beam pattern weight vector is generated by a transmit channel weight vector adaptation module 150 based on the results of the statistical characterization of the receive channel vector. This weight vector, $\mathbf{w}_T(t)$, optimizes a particular aspect (e.g., average desired signal to undesired interference ratio) of the signal energy within the transmission range of the base station array 56. In the exemplary embodiment, the optimal transmit beam pattern weight vector is generated using the estimated desired receive channel covariance matrix, $\hat{\mathbf{R}}_d(k)$, and undesired interference covariance matrix, $\hat{\mathbf{R}}_u(k)$, both of which are compiled within the covariance estimator 140.

As is indicated by Figure 3, the signal information (S_T) to be transmitted to the desired mobile radio unit is used to modulate a digital baseband carrier within a modulator 154. The modulated signal is then applied to a transmit channel weighting module 158 disposed to weight, on the basis of the optimized transmit pattern weight vector, the input signals corresponding to each element of the antenna array 56. The weighted set of input signals produced by the weighting module 158 are then upconverted in frequency within a complex frequency upconverter 160 of the RF transmitter 52. The resultant frequency-upconverted

signals are then amplified by a bank of power amplifiers 164, and provided to the antenna array 56 for transmission via diplexer 58.

In the exemplary embodiment an improved estimate of the received signal is obtained through utilization of a demodulator 170 and remodulator 172. The received signal is demodulated within demodulator 170 in order to recover the essential characteristics of the modulating signal. In the case of an analog FM signal, this involves recovery of the FM waveform. In the case of a digitally modulated signal (BPSK, FSK, QPSK, etc.), the demodulator 170 forms hard decisions as to the value of each digital symbol. The demodulated signal is then processed based upon some predefined characteristic of the signal and modulation pattern. For example, a demodulated analog FM signal could be lowpass filtered based upon a known signal information bandwidth as a means of obtaining an improved post-demodulation signal estimate. In the case of digital modulation, error correction could be implemented in order to remove bit errors, thus improving estimated signal quality. In addition, training signals (i.e., pilot tones, SAT tones, etc.) may optionally be employed in lieu of, or in conjunction with, the aforementioned "blind" techniques.

Again referring to Figure 3, the processed demodulated signal is then used by demodulator 172 to remodulate an RF carrier, thereby producing an improved modulated signal estimate. The improved signal estimate is then used by the receiver weight vector adaptation block 118 and the covariance estimate 140. Other techniques, which do not rely upon such a demodulation/remodulation procedure, can be devised for obtaining a sufficiently accurate received signal estimate. Figure 3 simply illustrates a particular exemplary embodiment incorporating a demodulator and remodulator.

In the present embodiment, the demodulator 170 and remodulator 172 or the receive channel beamformer 60 are operative to produce a received signal estimate $\hat{s}_r$. The quantity $\hat{S}_r$ is then employed by the covariance estimator 140 to estimate the covariance matrix of the receive channel. The receive channel beamformer 60 could of course be replaced by numerous alternative structures including, for example, multi-antenna sequence estimators, maximum likelihood receiver structures, multiple element decision feedback equalizers, or similar alternative described in Supplement

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1. Any of these alternative structures could also be used to provide the quantity $\hat{s}_r$ for use in estimating the received channel covariance statistics.

II. Blind Beamforming Using Multipath Signals

As mentioned above, an initial step within the present invention involves characterizing a receive channel vector representative of the multipath communications channel from a mobile user to a base station antenna array 56. In one embodiment, this is accomplished as described in Supplement 1. This embodiment employs a five step approach:

1) estimate the present signal sequence by passing the equalizer output through a decision device;

2) estimate the present channel state with an optimal estimation filter;

3) estimate the received interference plus noise signal sequence and use this error signal to update the interference covariance estimate;

4) update the spatial equalizer weight vector given the estimated desired channel and interference covariance; and

5) repeat the process with new desired signal estimates.

III. Alternate Embodiments

Although the embodiments of the invention presented herein have been described in terms of optimization from a base station perspective, the teachings of the invention are equally applicable to optimum formation of the mobile unit antenna pattern. That is, the mobile unit antenna pattern is formed such that a desired level of power is transmitted to the one or more base stations with which the mobile unit is in communication, and so that transmission power is minimized to the other base stations within the communication network. Again, an initial step in this antenna pattern optimization procedure involves statistically characterizing the mobile unit receive channel vector. The results of this statistical characterization are then used to determine the beam pattern weight vector which maximizes a predetermined quality parameter (e.g., signal to noise ratio) of the signal received by the intended base station(s), while minimizing signal transmission to other base stations. At the

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mobile station, the transmit antenna beam pattern is then generated in accordance with the transmit beam pattern weight vector.

Accordingly, in the following claims the term "central communications station" is intended to refer to either the base station or mobile unit configured to generate an optimized antenna beam pattern in accordance with the invention. When a base station comprises the central communications station, the mobile unit(s) in communication therewith are referred to as "remote communications station(s)". Conversely, when a mobile unit comprises the central communications station, the receiving base station(s) are identified as remote communications station(s).

While the present invention has been described with reference to a few specific embodiments, the description is illustrative of the invention and is not to be construed as limiting the invention. Various modifications may occur to those skilled in the art while remaining within the true spirit and scope of the invention as defined by the appended claims.

SUPPLEMENT 1

New blind adaptive spatial equalization techniques are proposed for severe multipath fading with co-channel interference. In rapidly fading environments, equalizer performance suffers with existing algorithms because the desired and interference channels change significantly over the update time interval. It is shown that for fast fading channels, conventional squared error equalizer cost functions can yield poor results. A new algorithm is proposed based on a variation of the SINR cost function coupled with optimal time varying channel estimation to improve signal tracking. In simulations, the algorithm achieves theoretically optimum time varying equalizer performance in extreme interference channels with narrow band FM signals and high velocity portables. These results are contrary to the widespread belief that high performance blind adaptive array processing is not possible for AMPS with severe combinations of Doppler spread, angle spread, and interference power.

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1. INTRODUCTION

The problem we consider is blind adaptive spatial equalization with a multiple antenna base station array for the purpose of increasing reverse link spectral efficiency (Erlangs/Hz/base station) by canceling interference and enhancing the desired signal over noise. In blind equalization, the equalizer weight vector adaptation relies on the structure of the transmitted signal rather than a known training signal. While these techniques may be applied at the portable unit, this paper focuses on spatial equalization at the base station receiver.

The communication channel formed between a portable wireless user and a base station varies with time. When the portable moves with high velocity, the time variation in the channel can become severe. Over the past decade, a large body of work has been devoted to blind spatial equalization in time invariant channels. However, less work has been reported for large Doppler-spread conditions. For certain communication signals, including narrow-band FM, the known existing equalizer algorithms fail to converge in rapidly fading environments. This occurs because the channel changes significantly over the time interval required to determine the next equalizer weight vector update.

In most conventional adaptive algorithms, the signal quality criteria is minimum mean squared error (MMSE). We will show that this criteria may not be the best choice in rapidly fading channels. We will also show that the signal to interference plus noise ratio (SINR) criteria can be more robust in rapidly fading channels. With this motivation, an algorithm is developed which adaptively optimizes an interesting variation of the conventional SINR criteria. The proposed equalizer decomposes the received vector signal into a desired signal subspace and an interference plus noise subspace. In order to accurately estimate these two subspaces, we exploit the inherent time correlation structure that exists in the fading channel to obtain instantaneous blind estimates of the desired channel.

The multiple antenna wireless channel model is briefly reviewed in Section 2. The spatial equalization problem is developed and a solution is proposed in Section 3. Simulation results demonstrating the performance of the adaptive spatial equalizer with multiple co-channel narrow-band analog FM signals in a high

Doppler spread, high angle spread fading environment are presented in Section 4. Conclusions are offered in Section 5.

2. CHANNEL MODELS

The wireless communication channel is characterized by scattering and reflecting bodies which cause severe multipath. This is illustrated in Figure 1. The channel is also time-varying when the receiver is in motion. The time-variation is characterized by rapid amplitude fluctuations and therefore is called a fading channel. These short-term complex amplitude variations are often well modeled by a multiplicative Gaussian random process. The channel also exhibits long-term variations which are due to shadowing by large physical features. This variation is much less structured and is sometimes well modeled as a log-normal multiplicative random variable.

Let $s_o(t)$ be the complex analytic baseband representation of the transmitted signal. If the remote transmitter has a single antenna and the wireless base station receiver has multiple antennas, then the direction of arrival of the lth path form the receiver (given by $\theta_{0,l}$) is of importance. The baseband vector output of the base station receiver dues to the lth propagation path is

$$x_l(t) = a(\theta_{0,l})\,\beta_{0,l}(t)\,s_0(t) \qquad (1)$$

where $a(\theta_{0,l})$ denotes the base station array response to the path arriving at the angle $\theta_{0,l}$. The composite complex-valued propagation path strength $\beta_{0,l}(t)$ is given by

$$B_{0,l}(t) = \frac{1}{d_0^{\frac{n}{2}}}\alpha_{0,l}(t)\cdot\sqrt{T_{0,l}} \qquad (2)$$

where $\alpha_{0,l}(t)$ is the complex fast fading parameter, Γ_l is the shadow fading loss factor, d_0 is the distance from the mobile to the base station and η is the path power-loss exponent. In Equation (1) an inherent assumption is that each propagation path amplitude is frequency invariant over the bandwidth of the signal and that the relative time delay between different arriving paths is small compared to the inverse signal bandwidth. Below, it is further assumed that the array response $a(\theta_{0,l})$ is

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invariant over the signal bandwidth. This set of conditions is commonly referred to as the narrow band assumption.

The received time-domain signal vector is the sum of all dominant reflector paths and the additive receiver noise n(t)

$$x(t) = \sum_{l=1}^{L} x_l(t) + n(t) = \sum_{l=1}^{L} a(\theta_{0,l})\,\beta_{0,l}(t)\,s_0(t) + n(t) \qquad (3)$$

Clearly from the above model, the time-varying response of the continuous-time desired portable channel is

$$h_0(t) = \sum_{l=1}^{L} a(\theta_{0,l})\,\beta_{0,l}(t) \qquad (4)$$

The channel given in Equation (3) is sampled at a rate of T seconds. The output samples can be rewritten as,

$$x_k = h_{0,k} s_{0,k} + n_k \qquad (5)$$

with the discrete time channel response given by

$$h_{0,k} = \sum_{l=1}^{L} a(\theta_{0,l})\,\beta_{0,l,k}$$

In the presence of multiple user co-channel interference, we have the received signal vector

$$x_k = h_{0,k} s_{0,k} + \sum_{j=1}^{P} h_{j,k} s_{j,k} + n_k \qquad (6)$$

When portables move at high velocities, giving rise to large Doppler frequency shifts, the channel vector complex M-space direction and magnitude become rapidly varying functions of time. The propagation environment determines the exact nature of the vector variation. The central path angle and relative spread in path angles (angle spread) for each channel determines the Eigenvectors and Eigenvalues of the time averaged vector subspace spanned by the channel. The Doppler spread determines the rate of time variation within the channel subspace.

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3. SPATIAL CHANNEL EQUALIZATION

The techniques proposed in this paper do not consider conventional antenna concepts such as beam width, gain and side lobe rejection. Instead, the antenna array is viewed from a statistical signal processing perspective. Each antenna array output represents a phase and amplitude coherent sensor which contains a weighted sum of the desired signal, the undesired signals, and noise. By applying an appropriate complex weight to each sensor signal and then summing the outputs, it is possible to cancel undesired interference and enhance the desired signal above the noise. The sensor weights are described by an equalizer weight vector w. If the weight vector is adapted in real time in an optimal manner, it is possible to achieve performance that is far superior to fixed beam systems. To implement a fully adaptive array, a bank of phase and amplitude coherent digital RF receivers is required. Recent technology advances in wide band digital RF converter technology make such systems not only feasible, but also economical. An Adaptive spatial equalizer conceptual diagram is illustrated in Figure 3.

3.1. Algorithm Cost Function

In order to adapt the spatial equalizer weight vector, it is necessary to define an equalizer signal quality optimization function. Here, we consider two possible cost functions, MMSE and maximum S1NR. We will show that for slowly varying channels, these cost functions are equivalent to within a scalar constant. We will also show that for rapidly varying channels, with a fixed equalizer weight applied to a finite block of received data, the two cost functions result in very different solutions and the maximum SINR criteria is often a more sensible choice. First, the slowly varying channel case is considered. Then the case where the channels fade rapidly with respect to the equalizer adaption rate is discussed.

Under the slowly varying channel condition, if perfect knowledge were available for the instantaneous desired channel, the instantaneous co-channel interference channels, the desired signal variane, the interference signal variances, and the noise variance, the well known "instantaneous" MMSE spatial equalizer solution is

$$W_{MSE,k} \doteq arg \min_{w} E\left\{|w^{*}x_{k}-s_{0,k}|^{2}\right\} = \sigma_{so}^{2}R_{xk}^{-1}h_{0,k} \qquad (7)$$

where $R_{x,k}$ is the "instantaneous covariance" matrix for the received signal vector defined by

$$R_{x,k} \doteq E\left\{x_k x_k^*\right\} = \sigma_{so}^2 h_{0,k} h_{0,k}^* + R_{u,k} \tag{8}$$

and $R_{u,k}$ is the instantaneous interference plus noise covariance matrix defined by

$$R_{u,k} \doteq \sum_{j=1}^{P} \sigma_{2j}^2 h_{j,k} h_{j,k}^* + \sigma_n^2 I \tag{9}$$

The above expressions are derived under the assumption that the desired signal, all interfering signals, and the noise are uncorrelated.

Given the same apriori knowledge, the maximum SINR problem is

$$w_{SNR,k} \doteq \arg \max_{w} \frac{E\left\{\left| w^* h_{0,k} s_{0,k} \right|^2\right\}}{E\left\{\left| w^* \left[\sum_{j=1}^{P} h_{j,k} s_{j,k} + n_k\right]\right|^2\right\}} \tag{10}$$

The solution for $W_{SNR,k}$ is easily derived as the generalized eigenvector associated with the maximum generalized eigenvalue of the matrix pencil

$$[h_{0,k} h_{0,k}^*, R_{u,k}]$$

which is equivalent to the solution

$$W_{SNR,k} = R_{u,k}^{-1} h_{0,k} \tag{11}$$

since

$$h_{0,k} h_{0,k}^*$$

is obviously rank 1. Using the matrix inversion lemma, we can prove that the MMSE solution to Equation (7) is equivalent to the maximum SINR solution to Equation (11) to within a scalar constant given by

$$w_{MSE,k} = \left(\frac{1}{h_{0,k}^* R_{u,k}^{-1} h_{0,k} + \frac{1}{\sigma_{so}^2}} \right) w_{SNR,k} \tag{12}$$

So, we conclude that with perfect instantaneous desired and undesired channel knowledge the MMSE and SINR cost functions lead to nearly identical solutions.

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In rapidly time varying channel setting, perfect instantaneous knowledge of the channels is not available. The channels often change appreciably over the adaptation interval of the equalizer algorithm. In such cases, there can be a substantial difference between the MMSE and SINR adaption criteria. Consider an adaptive spatial equalization algorithm based on an optimal MMSE solution similar to Equation (7), but the algorithm employs a sliding window of length N samples for each weight vector. Numerous proposed schemes apply a sliding window. The sliding window MMSE problem statement may be written as

$$w_{MSE,k}^{(N)} \doteq \arg \min_{w} E\left\{|| \; w^{*}X_k - s_{0,k}||_2^2\right\} \tag{13}$$

where the received signal vector sequence

$$X_k = [x_k \cdots x_{k-N+1}]$$

and the transmitted desired signal sequence

$$s_{0,k} = [s_{0,k} \cdots s_{0,k-N+1}]$$

Again assuming perfect knowledge of the channels, we can show that the solution is

$$W_{MSE}^{(N)}, k = \sigma_{sc}^2 \left[\sum_{j=0}^{P} \sigma_{sj}^2 \langle h_{j,k} h_{j,k}^{*} \rangle_N + \sigma_n^2 I\right]^{-1} \langle h_{0,k} \rangle_N \tag{14}$$

where

$$\langle (\cdot) \rangle_N = \frac{1}{N} \sum_{nx-oo}^{k} (\cdot) n$$

is the N-sample averaging operator. We can compare this finite block length solution to the ideal instantaneous solution to Equation (7) by re-writing Equation (14) as

$$W_{MSE,k}^{(N)} = \sigma_{sc}^2 \left[R_{s,k} + \Delta R_k\right]^{-1} \left[h_{0,k} + \Delta h_k\right] \tag{15}$$

where the covariance error term is

$$\Delta R_k = \frac{1}{N} \sum_{n=k-N+1}^{k-1} \sum_{j=0}^{P} \sigma_{sj}^2 h_{j,n} h_{j,n}^{*} - \frac{N-1}{N} \sum_{j=0}^{P} \sigma_{sj}^2 h_{j,k} h_{j,k}^{*} \tag{16}$$

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and the channel error term is

$$\Delta h_k = \frac{1}{N}\sum_{n=k-N+1}^{k-1} h_{0,n} - \frac{N-1}{N} h_{0,k} \qquad (17)$$

For a time varying channel, as N increases, the error terms in the finite block length solution increase. The effect of the covariance error ΔR_k is to add false components to the interference subspace in the equalizer solution. The effect of the channel error Δh_k is additive. The combination of these effects is highly non-linear. Thus, it is not clear that applying the MMSE criteria to finite length time blocks with rapidly fading channels will result in desirable performance. As a simple example, given the zero mean channel model from the previous section, it can be shown that

$$\lim_{N\to\infty} w_{MSE,k}^{(N)} = 0 \qquad (18)$$

which is clearly a useless solution. This motivates a search for cost functions which are more robust in time varying channels.

In contrast to the above, applying the SINR criteria to a block of received data always results in a useful equalizer solution, even in the limit. Carrying through a similar development for the SINR equalizer, we have

$$w_{SNR,k}^{(N)} \triangleq \arg\max_{w} \frac{E\left\{\left|w^*[h_{0,k}s_{0,k}\cdots h_{0,k-N+1}s_{0,k-N+1}]\right|_2^2\right\}}{E\left\{\left|w^*\left(\sum_{j=1}^{P}[h_{j,k}s_{j,k}\cdots h_{j,k-N+1}s_{j,k-N+1}]+[n_k\cdots n_{k-N+1}]\right)\right|\right|} \qquad (19)$$

The solution for

$$w_{SNR,k}^{(N)}$$

is the generalized eigenvector associated with the maximum generalized eigenvalue of the matrix pencil

$$\left|\langle h_{0,k}h_{0,k}^*\rangle_N ; \sum_{j=1}^{P}\sigma_{sj}^2\langle h_{j,k}h_{j,k}^*\rangle_N + \sigma_n^2 I\right|$$

This solution has a precise meaning: "Given N received samples and one equalizer weight vector setting, maximize the ratio of the average received signal energy divided by the average noise plus interference energy." The theoretically achievable

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SINR will decrease as N increases because the interference and desired signal covariance matrices will become more well conditioned thus reducing the maximum eigenvalue of the matrix pencil. However, this degradation is graceful and is easily

Equalizer Solution

(a)

$$[\sum_{i=1}^{P} \sigma_{sj}^2 h_{j,k} h_{j,k}^{*} + \sigma_n^2 I]^{-1} h_{0,k}$$

(b)

$$[\sum_{j=1}^{P} \sigma_{sj}^2 \langle h_{j,k} h_{j,k}^{*} \rangle_N + \sigma_n^2 I]^{-1} h_{0,k}$$

(c)

$$v_{max}(\langle h_{0,k} h_{0,k}^{*} \rangle_N, [\sum_{j=1}^{P} \sigma_{sj}^2 \langle h_{j,k} h_{j,k}^{*} \rangle_N + \sigma_n^2 I])$$

analyzed. This will be illustrated in Section 4.

It is also possible to use convenient combinations of instantaneous and average channel information to form variations on the SINR criteria. Three variations of the SINR equalizer are presented in Table 3.1. As we will see in the next section, it is also sometimes advantageous to replace the averaging operation

$$\langle (\cdot)\, k \rangle_N$$

with the exponentially weighted averaging operator given by

$$\langle (\cdot)\, k \rangle_\lambda \doteq \sum_{n=-\infty}^{k} \lambda^{k-n} (\cdot)_n \quad , \quad 0<\lambda<1 \qquad (20)$$

3.2 Algorithm Description

The highest potential equalizer performance is obtained with the SINR cost function based on the instantaneous desired channel and the instantaneous undesired interference subspace. A second solution is possible which is based on a short term time average interference subspace description and the instantaneous desired channel. The performance for this equalizer is lower than the first since the interference matrix includes subspace components from past interference channel states. The relative performance decrease is dependent on the angle of arrival spread

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and the product of the time window length and the Doppler frequency. A third equalizer solution involves subspace averaging for both the desired and undesired channels with still lower performance.

From the above, it would seem obvious to choose the instantaneous criteria. However, in time varying interference dominated channels, blind equalization algorithms which rely on signal property restoral are subject to false signal tracking. False tracking occurs when the instantaneous desired channel is in a deep fade and the algorithm converges to a stronger interference signal. With a time average interference covariance solution, the algorithm becomes less susceptible to false tracking as the effective interference subspace averaging window is increased. Thus, a trade-off exists between achieving the optimum instantaneous SINR performance and robust signal tracking. This motivates us to choose an SINR equalizer solution which has the form

$$\hat{w}_k = \frac{[(\hat{R}_{u,k})_\lambda]^{-1}\hat{h}_k}{\hat{h}_k^* [(\hat{R}_{u,k})_\lambda]^{-1}\hat{h}_k} \qquad (21)$$

where $(\cdot)$ implies an estimated value. We note that the trade-off between instantaneous SINR performance and tracking robustness can easily be adjusted by varying the forgetting factor λ. Increasing λ results in a decrease in the rate of false tracking occurrences, and a decrease in performance as compared to the ideal instantaneous solution. Several techniques are available to detect and recover from false tracking events, so signal quality is maintained as long as the occurrence rate is low. The proposed equalization strategy is divided into five steps which are

1. Estimate the present signal sequence by passing the equalizer output through a decision device. [Equations (22) and (23)].

2. Estimate the present channel state with an optimal estimation filter. [Equations (25) and (27)].

3. Estimate the received interference plus noise signal sequence. Use this error signal to update the interference covariance estimate. {Equations (30) and (31)].

4. Update the spatial equalizer weight vector given the estimated desired channel and interference covariance. [Equation (21)].

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5. Repeat the process with new desired signal estimates.

This adaptation procedure is represented by the block diagram shown in Figure 3. Each of the algorithm steps are described below.

Using the present equalizer setting, a short block of received data is equalized

$$\hat{s}_{0,k}=\hat{w}_k^* X_k=[\hat{s}_k \cdots \hat{s}_{k-N+1}] \quad (22)$$

The equalizer output is then passed through a non-linear detection function d(·) which restores some known property of the transmitted portable signal. In the case of an FM signal set, the nonlinear function can simply force the signal modulus to a constant value, or a more sophisticated combination modulus forcing and phase filtering function has been proposed. In the case of finite alphabet digital signals, the nonlinear function is a symbol waveform detector. The output of the detection function is the estimated signal sequence

$$\hat{s}_{0,k}=d(\hat{s}_{0,k}) \quad (23)$$

In order to accurately determine the interference subspace and the optimal weight vector, it is critical to have an accurate estimate of the desired channel. The channel exhibits highly structured time auto-correlation behavior for each antenna element. This structured variation should be exploited to improve our ability to identify and track the desired channel. The channel is estimated in two steps. First, a "measurement" of the reverse channel $h_{0,k}$ is obtained by solving

$$\hat{h}_{0,k}=arg\ \min_h ||h\hat{s}_{0,k}-X_k||_F^2 \quad (24)$$

Here, the channel is assumed time invariant over the data block. The data block must be a very small fraction of the inverse Doppler frequency to maintain this assumption. Assuming the noise plus interference is Gaussian, the solution to Equation (24) is the deterministic maximum likelihood estimate

$$\hat{h}_{0,k}=X_k\hat{S}_{0,k}^{\dagger} \quad (25)$$

The channel measurements defined by Equation (25), provide a true channel plus noise measurement model since

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$$Xk\hat{S}^{!}_{0,k}=h_{0,k}+Nk\hat{S}^{!}_{0,k}=h_{0,k}+u_k \quad (26)$$

where $N_\kappa=[n_\kappa \cdots n_{\kappa-N+1}]$ and u_κ is the equivalent channel measurement noise term

$$Nk\hat{S}^{!}_{0,k}$$

The final channel estimate is a weighted sum of the present and past channel measurements

$$\hat{h}k = \sum_{n=0}^{N-1} f_n \hat{h}_{k-n} \quad (27)$$

with the FIR filter vector f given by

$$f=arg \min_{f} E\left\{||\hat{h}_k - h_{0,k}||_2^2\right\} \quad (28)$$

The solution to Equation (28) is a Wiener filter given by

$$f=[E\{\beta_k\beta_k^*\}+E\{\mu_k\mu_k^*\}]^{-1}E\{\beta_k\beta_k^*\} \quad (29)$$

where

$$\beta_k=[\beta_k \cdots \beta_{k-N_{H,2}+1}]^T$$

is a vector of scalar fading variables representing the time varying complex amplitude of one channel vector entry in h_κ and $\mu_\kappa=$

$$[u_k \cdots uk-N_{2+1}]^T$$

is the corresponding time varying measurement noise vector for each entry in u_κ. The filter solution to Equation (29) can be based on ensemble average statistics or based on worst case sample path behavior. The ensemble average covariance function for β_κ is:

$$\sigma_\beta^2 J_o(w_d t)$$

The noise covariance is determined by the nature of the additive receiver noise and the short term cross-correlation and autocorrelation behavior of the interference signals.

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The solution for the channel estimation filter is also dependent on two

$$SNR\left(\frac{\sigma_{\beta}^{2}}{\sigma_{w}^{2}}\right)$$

variables, the maximum Doppler shift and the channel measurement . In the interest of complexity reduction, the filter design can be based on the maximum expected Doppler shift and the minimum expected SNR. Performance is enhanced if the Doppler and SNR are estimated and the filter coefficients are adapted either by resolving Equation (29) or by choosing the estimation filter from a fixed set of pre-computed possibilities.

To estimate the undesired interference subspace, the undesired signal sequence is estimated

$$\hat{X}_{u,k}=X_k-\hat{h}_k\hat{s}_{0,k} \tag{30}$$

The interference covariance estimate is then updated

$$\langle\hat{R}_{u,k}\rangle_{\lambda}=\lambda\hat{R}_{u,k-1}+\hat{X}_{u,k}\hat{X}_{u,k}^{*} \tag{31}$$

The weight vector is now given by Equation (21). The sample index κ is incremented by N and the next iteration is initiated.

It should be noted that many variations on this basic algorithm are possible. Several implementations involving sample by sample recursions have been evaluation. The FIR channel estimation filter can be replaced by an observer based filter with various state-space model possibilities. The fundamental contributions are the blind SINR adaption criteria, the subspace decomposition and the use of correlated desired channel behavior to improve estimation accuracy for the desired channel and the interference subspace.

4. SIMULATIONS

Simulations have been conducted to test the spatial equalizer approach discussed in the previous section. The signals are narrow-band FM with the following parameters:

f_o = 1GHz (RF center frequency)

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f_D	=	$\pm$103Hz (v = 70mph)
B_{voice}	=	4KHz (voice waveform bandwidth)
Δf_{voice}	=	$\pm$12KHz (peak voice FM excursion)
f_{SAT}	=	6KHz (SAT tone offset)
Δf_{SAT}	=	$\pm$2KHz (peak SAT tone FM excursion)

Here, we present one example simulation scenario in which the base station antenna is a six element linear array with inter-element spacing of $\lambda/2$. There are three transmitted mobile signals, each with equal average strength. Each signal arrives from four different paths. Each of the four paths for each signal are spread over a 30° range. Each path for each signal has independent fading generated by 10 randomly located local scatterers. The central path angles of arrival for the three signals are 40°, 20° and -70°. Complex Gaussian band limited noise is added at the output of each antenna element. The ratio of the time averaged received signal power to average additive noise power is 20dB per element. As the instantaneous channel fades, the instantaneous signal to additive noise power at each element varies above and below 20dB.

The blind spatial equalization algorithm described in the previous section was used to recover estimates for each of the three FM signals. The detection function $d(\cdot)$ is the complex sign. The data block length NT is 200μS with a corresponding adaptation rate of 5KHz. This is sufficient to support the assumption that the channel is constant over each block. The blind algorithm restarts when false signal tracking events are detected. False tracking detection can be implemented by several methods including monitoring SAT tone quality.

The instantaneous SINR for the recovered signal waveforms $\tilde{s}_{0,k}$ at the output of the spatial equalizer for each of the three signal estimates is plotted (solid) along with the corresponding optimum theoretical instantaneous SINR performance (dash) in Figures 4 through 6. The instantaneous SINR for one omni-directional antenna element (dash-dot) is also plotted to provide a reference for SINR improvement. Optimum performance is determined by the maximum eigenvalue of the instantaneous matrix pencil

$$[h_{0,k}h_{0,k}^{*}; R_{u,k}]$$

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All three simulation runs were performed on the same data set with the same initial weight vector setting. The only difference is the signal selected for tracking. Conventional CM algorithms were also applied to the simulated data set. None of the CM algorithms were found to converge to any of the three signals.

The one second time average estimated signal SINR for signals 1 through 3 is 18.8dB, 17.2dB and 15.7dB. The average estimated signal SINR loss with respect to the optimal instantaneous solution is 0.7dB, 1.9dB, and 3.8dB respectively. This is accounted for by the performance loss associated with the subspace forgetting factor λ. Figure 4 illustrates the theoretical limits for instantaneous SINR performance sacrifice for signal 3 due to increasing the interference subspace forgetting factor λ. In Figure 4, the optimal instantaneous SINR solution (solid) is plotted along with the maximum eigenvalue of the pencil

$$[h_{0,k}h_{0,k}^{*}, \langle R_{u,k}\rangle\lambda]$$

(dash) with $\lambda = 0.9999$ which approaches infinite averaging. The theoretical performance penalty, averaged over one second, between the optimal instantaneous interference covariance solution and the infinite average interference covariance solution is 4.6dB for the signal 3 example. These simulation results suggest that the proposed algorithm achieves optimal theoretical performance when the theoretical penalty due to interference subspace averaging is taken into account.

CONCLUSIONS

A new approach for blind adaptive spatial equalization in rapidly fading channels has been developed. The algorithm performs well in an extreme narrow band FM communication environment with high Doppler spread, high angle spread, and strong multiple co-channel interferers. We believe that these are the first reported results for a blind spatial equalizer which performs well on AMPS type signals in a high velocity portable multipath setting. The approach involves two fundamental results:

1. For certain communication signals in rapidly fading channel settings, a modified version of the SINR adaptive equalizer cost function is superior to conventional squared error cost functions.

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2. Optimal estimation techniques can be applied to obtain accurate channel estimates in the presence of noise and interference. High quality channel estimates are crucial to obtaining an accurate estimate of the interference subspace used to determine the SINR equalizer solution.

Extensions of our approach have been developed for multiple antenna delay-spread digital FIR communication channels. These time varying space-time equalizer results will be reported in a future paper.

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WHAT IS CLAIMED IS:

1. A base station for communicating over a radio network with a remote station, comprising:

a plurality of antennas and receivers to receive inbound information signals from the remote station;

a signal processor coupled to said receivers and configured to compute a plurality of weights for the purpose of weighting each of the receiver information signals and combining said weighted signals together in a manner that improves the signal quality at the output of said signal processor for both geographically stationary and rapidly moving remote stations.

2. The base station of claim 1, wherein said signal processor includes:

means for statistically characterizing a receive channel vector, said receive channel vector being representative of a receive communications channel over which signal energy is transmitted from said at least one remote communications station to said central communications station; and

means for generating said plurality of weights based on results of statistical characterization of said receive channel vector.

3. The base station of claim 2, wherein said signal processor includes:

one or more time-varying channel estimation filters for estimating said receive channel vector.

4. The base station of claim 2, wherein said means for statistically characterizing further include means for compiling an estimated receive channel covariance matrix.

5. The base station of claim 4, wherein said means for generating said beam pattern weight vector includes means for averaging said estimated receive channel covariance matrix in order to form an estimated transmit channel covariance matrix.

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6. The base station of claim 5, further including means for using said estimated transmit channel covariance matrix to form objective and constraint functions, said beam pattern weight vector being obtained by solving said objective and constraint functions.

7. A method of communicating over a radio network with a remote station using a base station having a plurality of antennas and receivers and a signal processor, said method comprising the steps of:

receiving inbound information signals from the remote station via said plurality of antennas and receivers;

computing a plurality of weights in said signal processor for the purpose of weighting each of the receiver information signals and combining said weighted signals together in a manner that improves the signal quality at the output of said signal processor for both geographically stationary and rapidly moving remote stations.

8. The method of claim 7, wherein said computing step includes the steps of:

statistically characterizing a receive channel vector, said receive channel vector being representative of a receive communications channel over which signal energy is transmitted from said at least one remote communications station to said central communications station; and

generating said plurality of weights based on results of statistical characterization of said receive channel vector.

9. The method of claim 8, wherein said method further includes the step of:

estimating said receive channel vector.

10. The method of claim 8, wherein said statistically characterizing step includes the step of:

compiling an estimated receive channel covariance matrix.

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11. The method of claim 10, wherein said generating said beam pattern weight vector step includes the step of:

averaging said estimated receive channel covariance matrix in order to form an estimated transmit channel covariance matrix.

12. The method of claim 11, further comprising the step of:

using said estimated transmit channel covariance matrix to form objective and constraint functions, said beam pattern weight vector being obtained by solving said objective and constraint functions.

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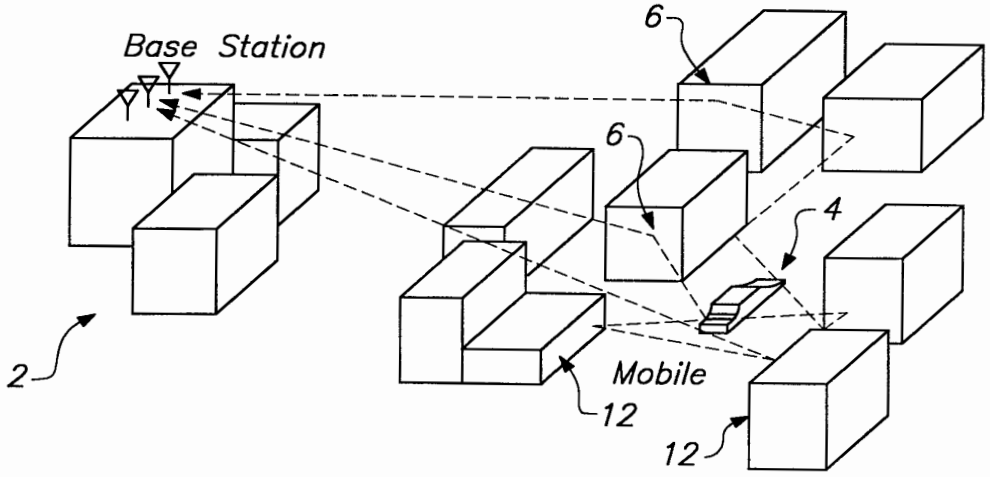

FIG. 1

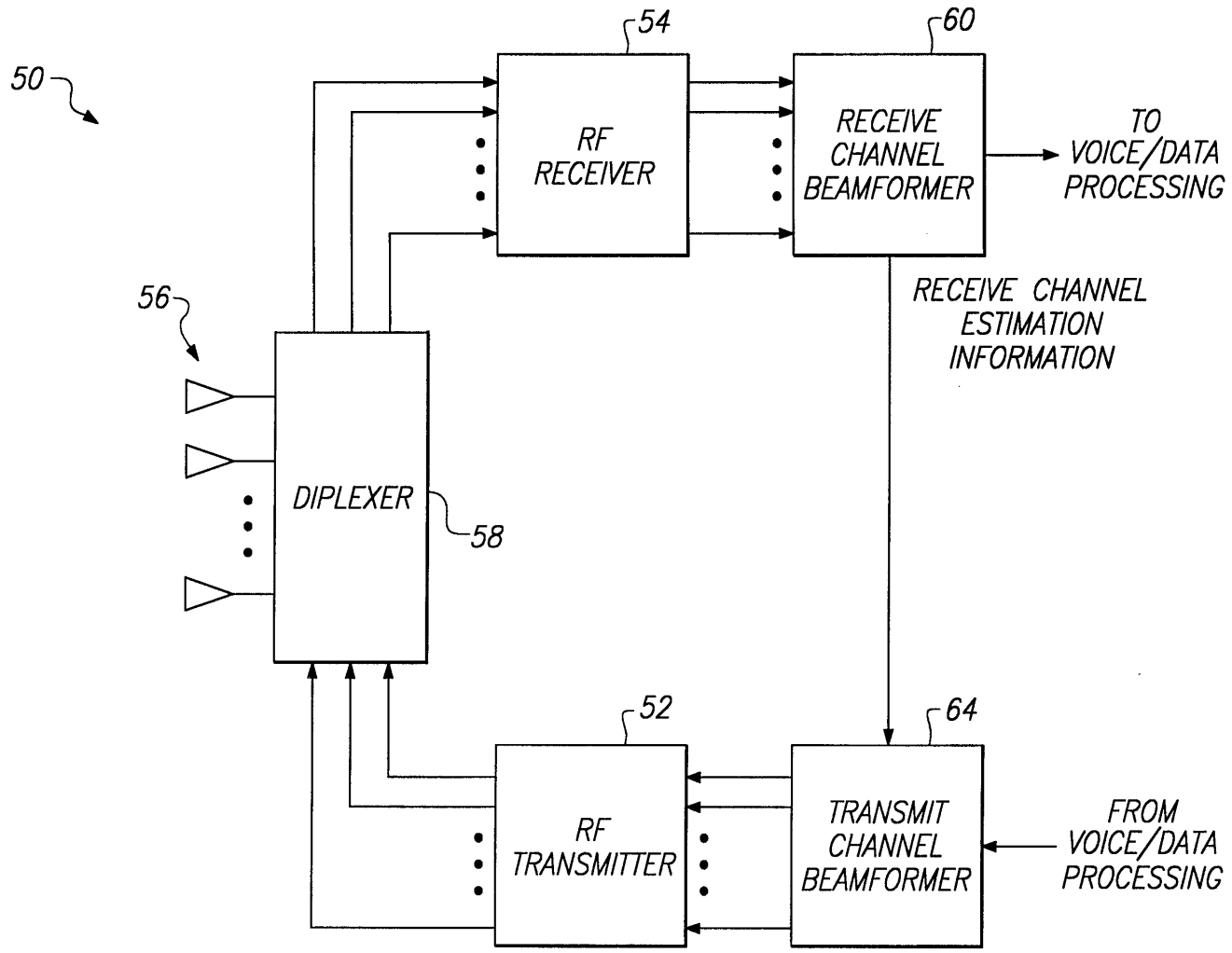

FIG. 2A

SUBSTITUTE SHEET (RULE 26)

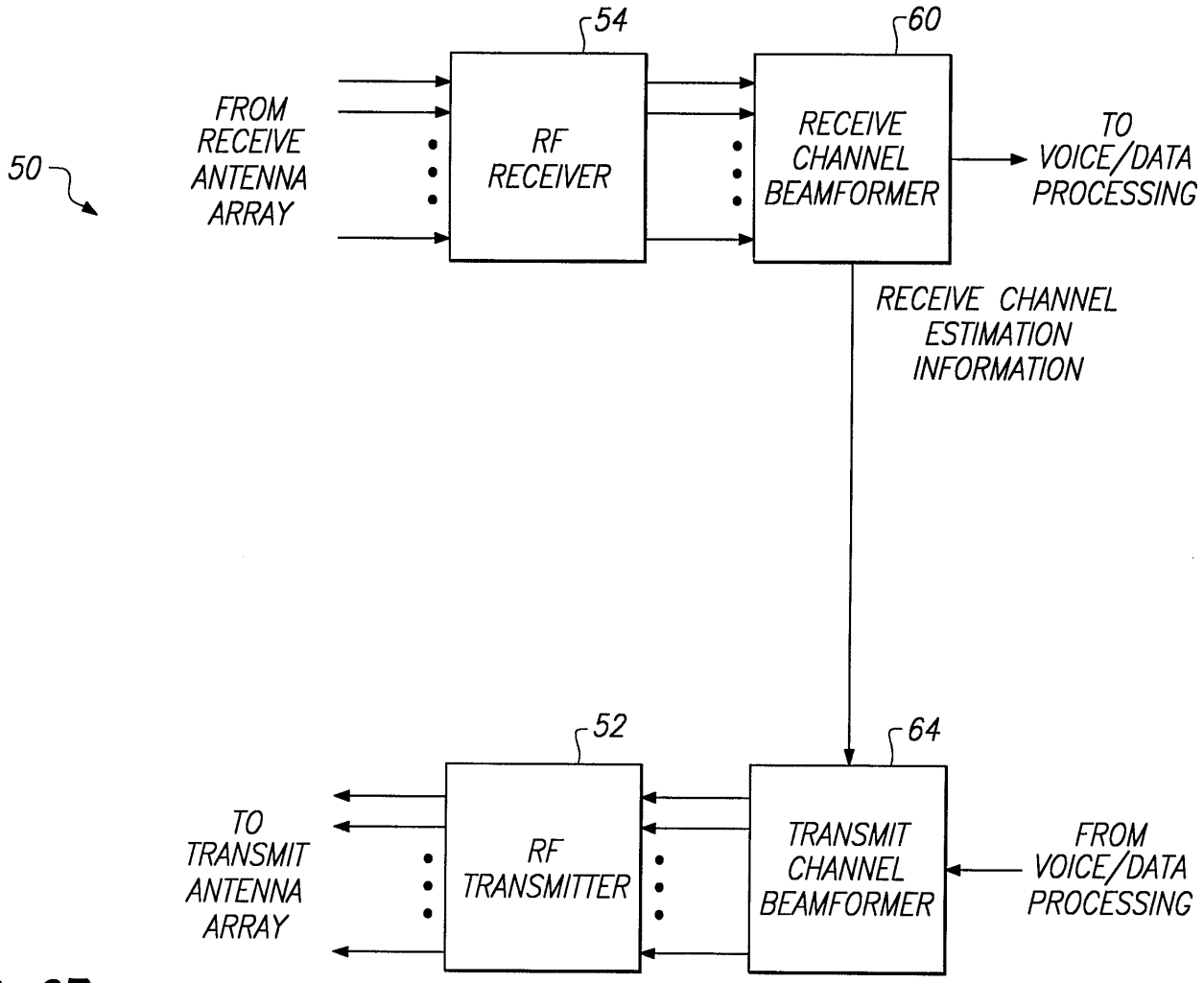

FIG. 2B

SUBSTITUTE SHEET (RULE 26)

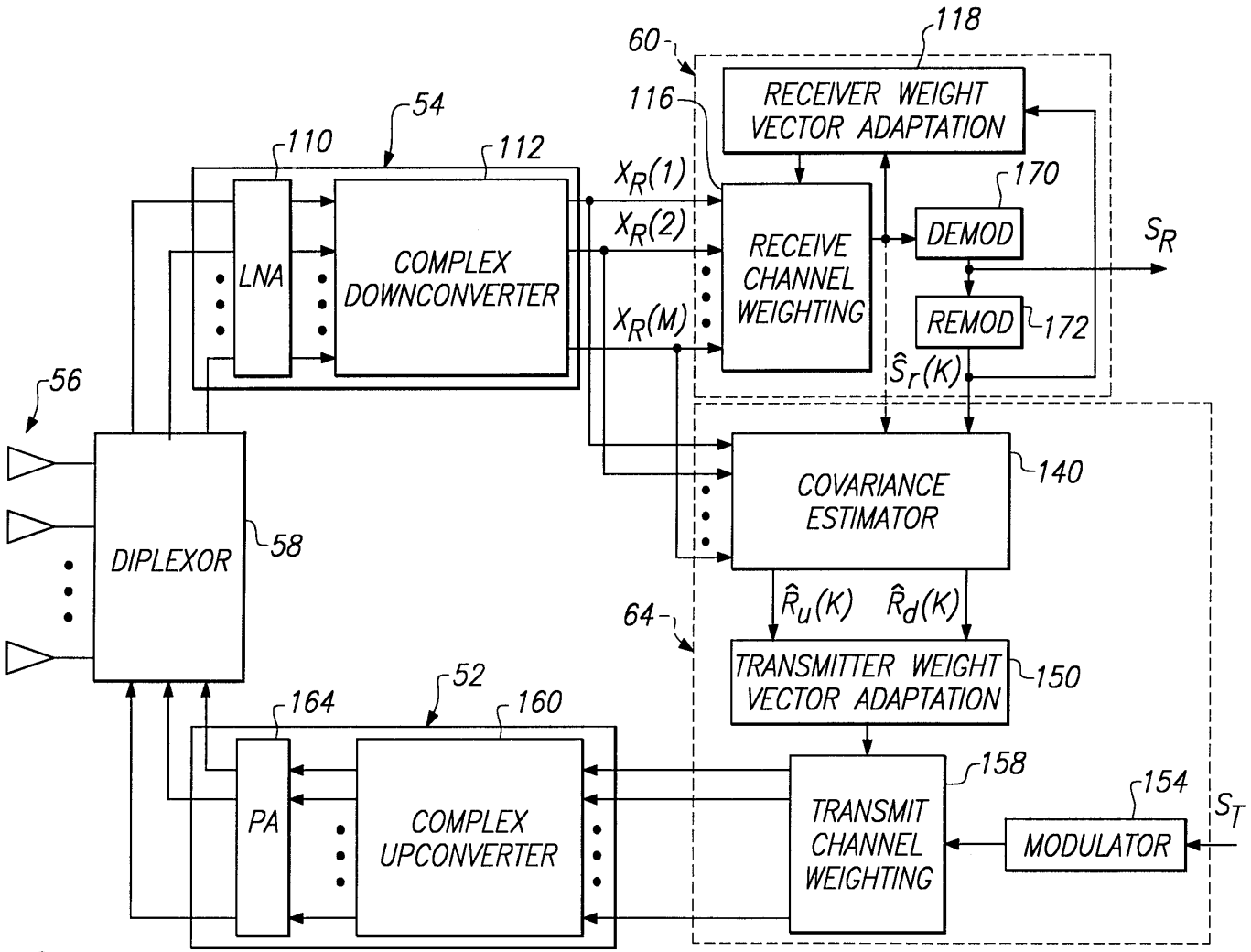
60
118
RECEIVER WEIGHT VECTOR ADAPTATION
116
54
110
112
$X_R(1)$
$X_R(2)$
$X_R(M)$
LNA
COMPLEX DOWNCONVERTER
RECEIVE CHANNEL WEIGHTING
170
DEMOD
S_R
REMOD
172
$\hat{S}_r(K)$
56
DIPLEXOR
58
COVARIANCE ESTIMATOR
140
$\hat{R}_u(K)$ $\hat{R}_d(K)$
64
TRANSMITTER WEIGHT VECTOR ADAPTATION
150
52
164
160
PA
COMPLEX UPCONVERTER
158
TRANSMIT CHANNEL WEIGHTING
154
MODULATOR
S_T

FIG. 3

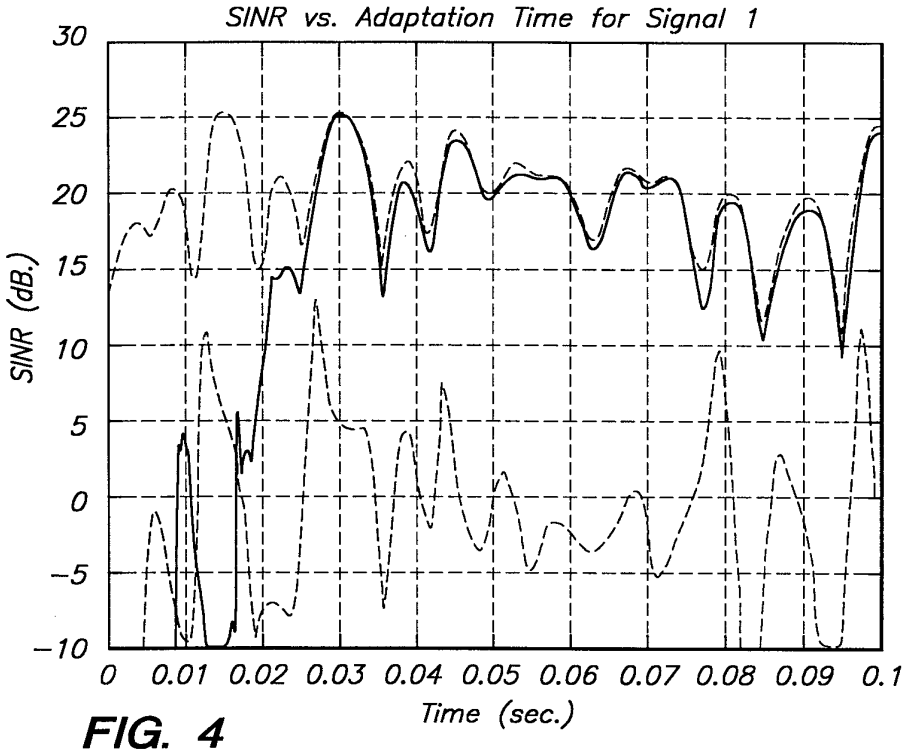
SINR vs. Adaptation Time for Signal 1
SINR (dB.)
30
25
20
15
10
5
0
−5
−10
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Time (sec.)

FIG. 4

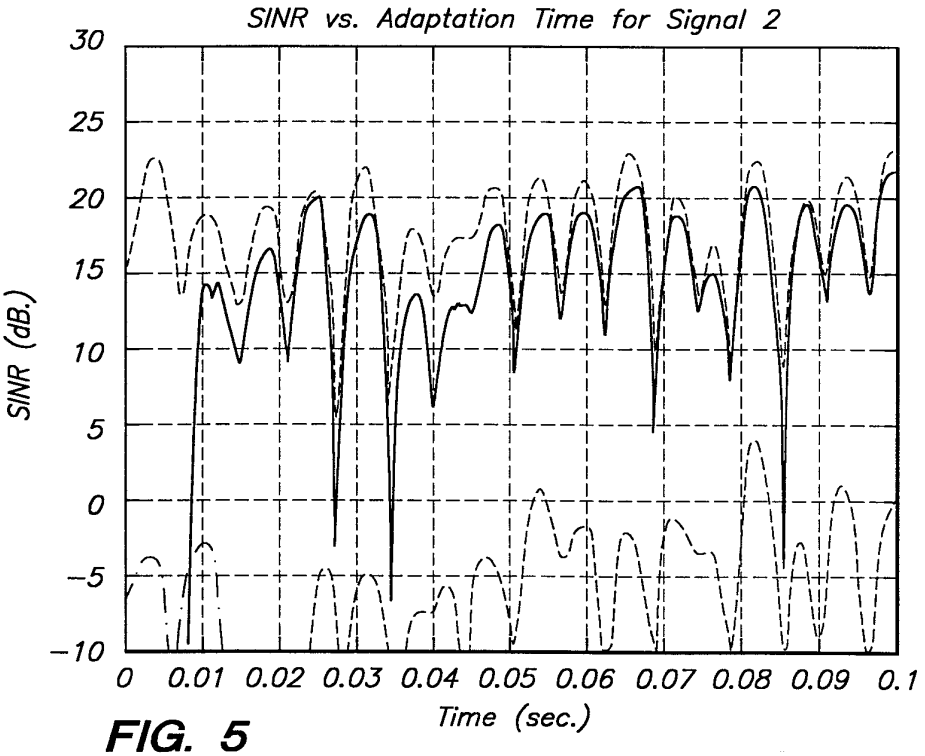
SINR vs. Adaptation Time for Signal 2
SINR (dB.)
30
25
20
15
10
5
0
−5
−10
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Time (sec.)

FIG. 5

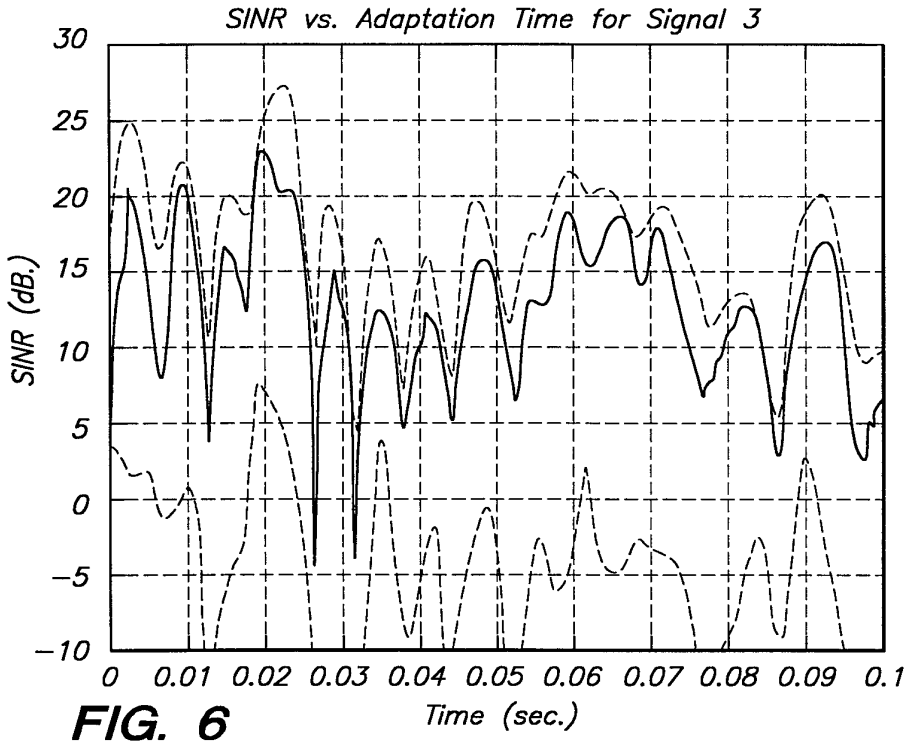
SINR vs. Adaptation Time for Signal 3
SINR (dB.)
30
25
20
15
10
5
0
−5
−10
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Time (sec.)

FIG. 6

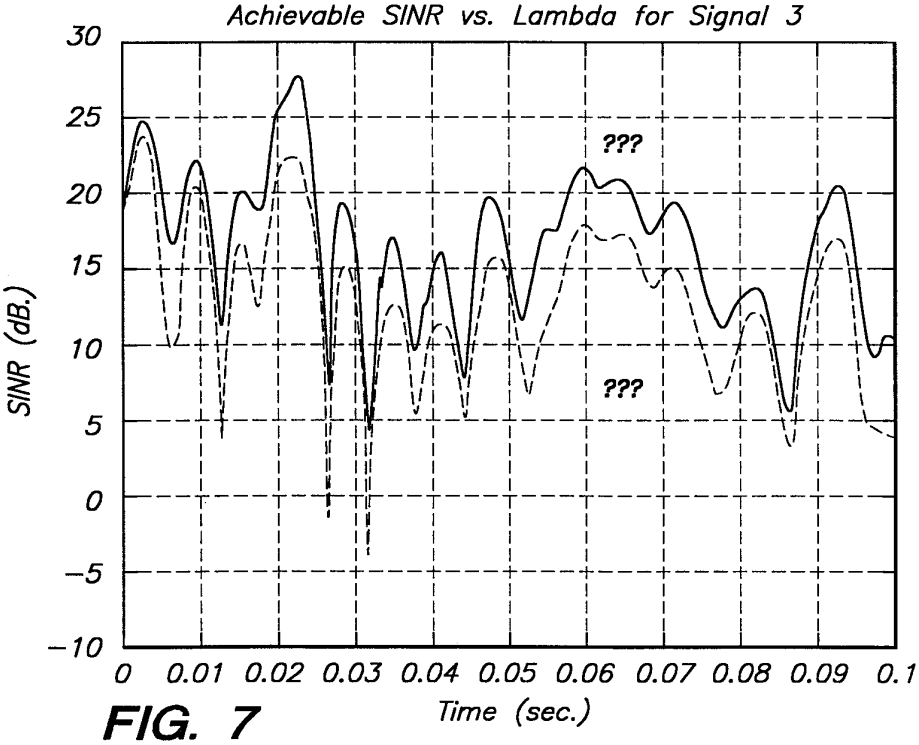
Achievable SINR vs. Lambda for Signal 3
SINR (dB.)
30
25
20
15
10
5
0
−5
−10
???
???
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Time (sec.)

FIG. 7

INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/US 97/18196

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/04 H01Q3/26 H01Q25/00 H04Q7/36 H04B7/005

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)
IPC 6 H04B H04Q 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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 515 378 A (ROY III RICHARD H ET AL) 7 May 1996 * abstract * see column 5, line 65 - column 6, line 14 see column 8, line 11 - line 33 see column 8, line 45 - line 61 see column 9, line 23 - column 10, line 21 see column 13, line 8 - column 14, line 10 see column 16, line 5 - line 16 see claims 1,5; figures 4,5,8 --- -/--	1,2,4,7, 8,10

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

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
25 May 1998	12/06/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/US 97/18196

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 97 00543 A (WATKINS JOHNSON CO ;UNIV LELAND STANFORD JUNIOR (US)) 3 January 1997 * abstract * see page 4, line 15 - page 5, line 16 see page 7, line 3 - line 16 see page 8, line 6 - page 9, line 12 see page 10, line 7 - line 23 see page 11, line 5 - line 20 see page 17, line 9 - line 20 see figures 2,3	1,12
A	WO 95 34997 A (BODIN ROLAND STIG ;ERICSSON TELEFON AB L M (SE); FORSSEN ULF GOERA) 21 December 1995 * abstract * see page 3, line 5 - page 4, line 14 see page 5, line 22 - page 6, line 8 see page 6, line 28 - page 7, line 7 see page 7, line 15 - line 31 see claim 1; figures 2,3,5	1,7
A	WO 94 09568 A (E SYSTEMS INC) 28 April 1994 * abstract * see page 3, line 16 - page 4, line 16 see page 5, line 19 - page 6, line 15 see page 7, line 14 - page 8, line 20 see figure 2	1,7
A	NORTH R C ET AL: "Multichannel adaptive equalization for improved performance in LOS digital radio" 1994 IEEE MILCOM. CONFERENCE RECORD (CAT. NO.94CH34009), PROCEEDINGS OF MILCOM '94, FORT MONMOUTH, NJ, USA, 2-5 OCT. 1994, ISBN 0-7803-1828-5, 1994, NEW YORK, NY, USA, IEEE, USA, pages 117-122 vol.1, XP002065786 see page 117, left-hand column, line 1 - right-hand column, line 36	1,7

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IPR2024-00148

INTERNATIONAL SEARCH REPORT

Information on patent family members

Internal Application No
PCT/US 97/18196

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		AU 3145493 A	19-07-93
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		EP 0616742 A	28-09-94
		FI 942771 A	10-06-94
		JP 7505017 T	01-06-95
		WO 9312590 A	24-06-93
		WO 9818272 A	30-04-98
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WO 9409568 A	28-04-94	AU 5354294 A	09-05-94

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IPR2024-00148

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(74) Agent: ALBIHNS PATENTBYRÅ MALMÖ AB; P.O. Box 4289, S–203 14 Malmö (SE).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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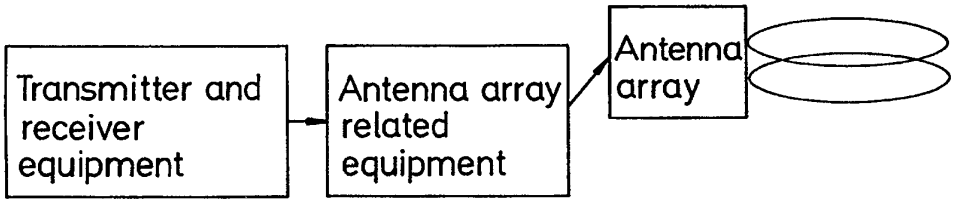
(54) Title: SEAMLESS LOBE HANDOVER



(57) Abstract

The present invention relates to a method in a telecommunication system for communication between mobile stations and base station sites in the telecommunication system. The mobile stations in said telecommunication system, preferably a cellular mobile radio system, move within a site on the same channel by use of seamless lobe or sector handover.

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APPLICANT: RADIO DESIGN INNOVATION TJ AB
TITLE OF INVENTION: SEAMLESS LOBE HANDOVER

Field of invention

The present invention relates to a method in a telecommunication system for communication between mobile stations and at least one base station site in said telecommunication system.

Prior art

Figure 1 discloses a schematic diagram of a flexible lobe shaping system. The antenna array has preferably eight antenna elements.

Each frequency channel has its own set of weights (e.g. $W_1(1) - W_8(1)$ in Figure 1). The number of these weights is determined by the number of antenna elements used.

The number of weight sets is determined by the number of simultaneously channels. Each frequency channel has one set of weights and if SDMA (Spatial Division Multiple Access) is used there must be several weight settings for each frequency channel.

No. Of weight sets = No. of frequency channels × SDMA factor.

No. of complex weights = No. of frequency channels × SDMA factor × number of antenna elements.

The lobe shaping system of Figure 1 is described in detail in the pending applications 9601613-4 (Method and Arrangement of Converting a Cellular Telecommunication System, Applicant: Radio Design AB), 9601615-9 (Rotating Lobe Access Method, Applicant: Radio Design AB) and 9601614-2 (Antenna System, Applicant: Radio Design AB) , which applications are incorporated herein by reference.

A problem with this flexible lobe shaping system is that it is very expensive to implement since much equipment is used.

A less hardware-consuming and thus less expensive solution is the fixed lobe-shaping system as can be seen in Figure 2.

The object of this invention is to avoid the changing of channel when hand-over is carried out in for example the above mentioned fixed lobe-shaping system.

CONFIRMATION COPY

Another object of the invention is to avoid the changing of receiver/transmitter equipment in the base station site.

Brief description of the invention

The above object is achieved by means of a method in a telecommunication system for communication between mobile stations and at least one base station site in said telecommunication system, wherein said mobile stations move within said base station site on a channel by use of seamless lobe/sector handover.

Handover without changing transmitter/receiver equipment implies increased capacity since it results in better trunking efficiency at the base station site.

Other features of the invention are set out in the dependent claims.

Brief description of the drawings

Figure 1 is a flexible lobe-shaping system;

Figure 2 is a fixed lobe-shaping system according to the invention;

Figure 3 is a block diagram of the system in Figure 2;

Figure 4 discloses adjacent fixed lobes with three excited antenna panels according to the invention;

Figure 5 discloses a base station site with three sectors comprising one lobe each, and with one antenna per sector;

Figure 6 discloses a base station site according to the invention with three sectors comprising five lobes each, and one antenna array per sector;

Figure 7 discloses a base station site according to the invention with three sectors comprising five lobes each, and one antenna array for all sectors;

Figure 8 discloses a base station site according to the invention with one sector comprising fifteen lobes and one antenna array for said sector;

Figures 9-12 disclose different structures of the lobe shaping system according to the invention.

Detailed description of an embodiment of the invention

The invention preferably refers to handover between lobes without changing channel. This implies that the mobile terminal can move within a site on the same channel by use of seamless lobe handover. The handover is seamless in the meaning that it can not be noted by the mobile user.

The invention will now be described with reference to Figures 3-12.

Figure 2 discloses an implementation of the block diagram in Figure 3. TRX in Figure 2 corresponds to transmitter and receiver equipment in Figures 3, 9-12. LF1 – LFn and the antennas in Figure 2 correspond to the Antenna array related equipment and the antenna array in Figures 3, 10, 12, respectively.

The cellular mobile radio system of the invention includes several base

station sites and mobile stations (terminals). Each base station site has one or more sectors divided into a number of fixed lobes (Figures 4-8). The base station site comprises base stations with base station transmitter equipment and a base station receiver equipment. The mobile station comprises a mobile station receiver and a mobile station transmitter. The communication in the cellular mobile radio system between a base station site and a mobile station is achieved by the following steps. As mentioned above each base station site uses a number of fixed lobes (Figures 4-8) in accordance with Figures 2, 3, 9-12. A connection is established between the base station site transmitter/receiver equipment and a mobile station. One of the lobes in one of the sectors of the base station site is used for transmission of signals between base station site transmitter/receiver and mobile station transmitter/receiver. The base station site continuously measures the signals received from the mobile station. For example the base station site determines the best lobe by comparing the signal received in actual lobe with signal received in alternative lobes. This can be carried out by comparing received signal strength or by comparing received signal to interference ratio in each lobe.

This comparison between signal strengths etc. in the lobes may imply a handover between the lobes. When the handover is performed the base station site changes utilized lobe of the base station site to another lobe of the same base station site without changing the serving transmitter and receiver equipment, i.e. the base station site uses the same transmitter/receiver equipment for the new lobe.

In another embodiment of the invention the base station site also changes transmitter/receiver equipment when changing lobe.

Thus, the channel is not changed when changing lobe. It should be realized that with channel we mean frequency, time slot, CDMA-coding etc. It should also be realized that instead of effecting handover between lobes as mentioned above, handover between sectors can also be achieved in the same manner.

A number of different handover situations will now be described with reference particularly to Figures 5-12. First the concept "base station site" will be explained with reference to Figure 6. The concept "base station site" in Figure 6 is defined as the covering area of the three sectors, and the base station site includes the three antenna arrays which normally are controlled by three base stations, i.e. one base station for each antenna array.

As mentioned above handover (HO) can be performed between different lobes and different sectors in a base station site. As disclosed in Figure 5 a base station site can consist of three different physical antennas, each connected to a base station, wherein handover can be performed between these antennas (base stations). This is the case in Figures 5, 11 in which lobe/sector handover is performed changing from sector 1 to sector 2. The transmitter/receiver equipment (TRX) controlling sector 1 is changed during handover to another transmitter/re-

ceiver equipment for sector 2. However, the same channel is used.

Another possibility is described in Figures 5, 9. In this case lobe/sector handover is performed changing from sector 1 to sector 2 but the same transmitter/receiver equipment of the base station site is used. The same channel or another channel can be used.

In Figures 3 and 6, lobe handover within a sector is performed without changing transmitter/receiver equipment. Same or changed channel can be used.

In Figures 6 and 12 sector/lobe handover is performed changing from one sector and corresponding TRX1 to another sector and corresponding TRX2. Same or changed channel can be used.

In Figures 3 and 7 lobe handover between lobes 4 and 5 is either performed within a sector or a lobe/sector handover is performed between sectors 6 and 7, wherein handover is performed from lobe 8 in sector 6 to lobe 9 in sector 7. In this case the same TRX equipment is used and the same or changed channel can be used.

In Figures 6, 10 lobe/sector handover is performed changing from one sector to another sector but the same transmitter/receiver equipment of the base station site is used.

The above is only to be considered as a preferable embodiment, and the scope of the invention is only limited by the following claims.

CLAIMS

1. A method in a telecommunication system for communication between mobile stations and at least one base station site in said telecommunication system, **characterized** in that said mobile stations move within said at least one base station site on a channel by use of seamless lobe handover.

2. A method as claimed in claim 1, **characterized** in that said telecommunication system includes said at least one base station site having one or more sectors each divided into a number of fixed lobes comprising the steps of:

- establishing a connection between a base station site transmitter/receiver equipment in said at least one base station site and a mobile station;

- transmitting signals from said base station site transmitter equipment to said mobile station receiver and transmitting signals from said mobile station transmitter to said base station site receiver equipment by utilizing one of said lobes in one of the sectors of said base station;

- changing said utilized lobe of said at least one base station site to another lobe of said at least one base station site without changing transmitter/receiver equipment of said base station site.

3. A method as claimed in claim 1, **characterized** in that said telecommunication system includes said at least one base station site having one or more sectors each divided into a number of fixed lobes comprising the steps of:

- establishing a connection between a base station site transmitter/receiver equipment in said at least one base station site and a mobile station;

- transmitting signals from said base station site transmitter equipment to said mobile station receiver and transmitting signals from said mobile station transmitter to said base station site receiver equipment by utilizing one of said lobes in one of the sectors of said base station;

- changing said utilized lobe and corresponding transmitter/receiver equipment (TRX1) of said at least one base station site to another lobe and corresponding transmitter/receiver equipment (TRX2) of said base station site.

4. A method as claimed in any of the preceding claims, **characterized** in that an antenna array and its supporting equipment is used to form fixed lobes.

5. A method as claimed in any of the preceding claims, **characterized** in that the channel is not changed when changing lobe.

6. A method as claimed in claim 5, **characterized** in that the change of the lobe is made without any signalling or channel order to and from said base station site to control the change of the lobe.

7. A method as claimed in any of claims 1-4, **characterized** in that said channel is changed when changing lobe.

8. A method as claimed in any of the preceding claims, **characterized** in that equipment in said base station site determines the best lobe by comparing signals

received in actual lobe with signals received in adjacent lobes.

9. A method as claimed in claim 8, **characterized** in that signals are compared by detecting received signal strength.

10. A method as claimed in claim 8, **characterized** in that signals are compared by evaluating received signal to interference ratio.

11. A method in a telecommunication system for communication between mobile stations and at least one base station site in said telecommunication system, **characterized** in that said mobile stations move within said at least one base station site on a channel by use of seamless sector handover.

12. A method as claimed in claim 11, **characterized** in that said telecommunication system includes said at least one base station site having a plurality of sectors comprising the steps of:

- establishing a connection between a base station site transmitter/receiver equipment in said at least one base station site and a mobile station;
- transmitting signals from said base station site transmitter to said mobile station receiver and transmitting signals from said mobile station transmitter to said base station site receiver equipment by utilizing one of the sectors in said base station site;
- changing utilized sector in said base station site to another sector in said base station site without changing transmitter/receiver equipment of said base station site.

13. A method as claimed in claim 11, **characterized** in that said telecommunication system includes said at least one base station site having a plurality of sectors comprising the steps of:

- establishing a connection between a base station site transmitter/receiver equipment and a mobile station;
- transmitting signals from said base station site transmitter to said mobile station receiver and transmitting signals from said mobile station transmitter to said base station site receiver equipment by utilizing one of the sectors in said base station site;
- changing utilized sector and corresponding transmitter/receiver equipment (TRX1) of said at least one base station site to another sector and corresponding transmitter/receiver equipment (TRX2) of said at least one base station site.

14. A method as claimed in any of claims 11-13, **characterized** in that said channel is not changed when changing sector.

15. A method as claimed in any of claims 11-14, **characterized** in that said change of sector is made without any signalling or channel order to and from said base station site to control said change of sector.

16. A method as claimed in any of claims 11-13, **characterized** in that said channel is changed when changing sector.

17. A method as claimed in any of claims 11-16, **characterized** in that equipment in said base station site determines the best sector by comparing signals received in actual sector with signals received in adjacent sectors.

18. A method as claimed in claim 17, **characterized** in that said signals are compared by detecting received signal strength.

19. A method as claimed in claim 17, **characterized** in that said signals are compared by evaluating received signal to interference ratio.

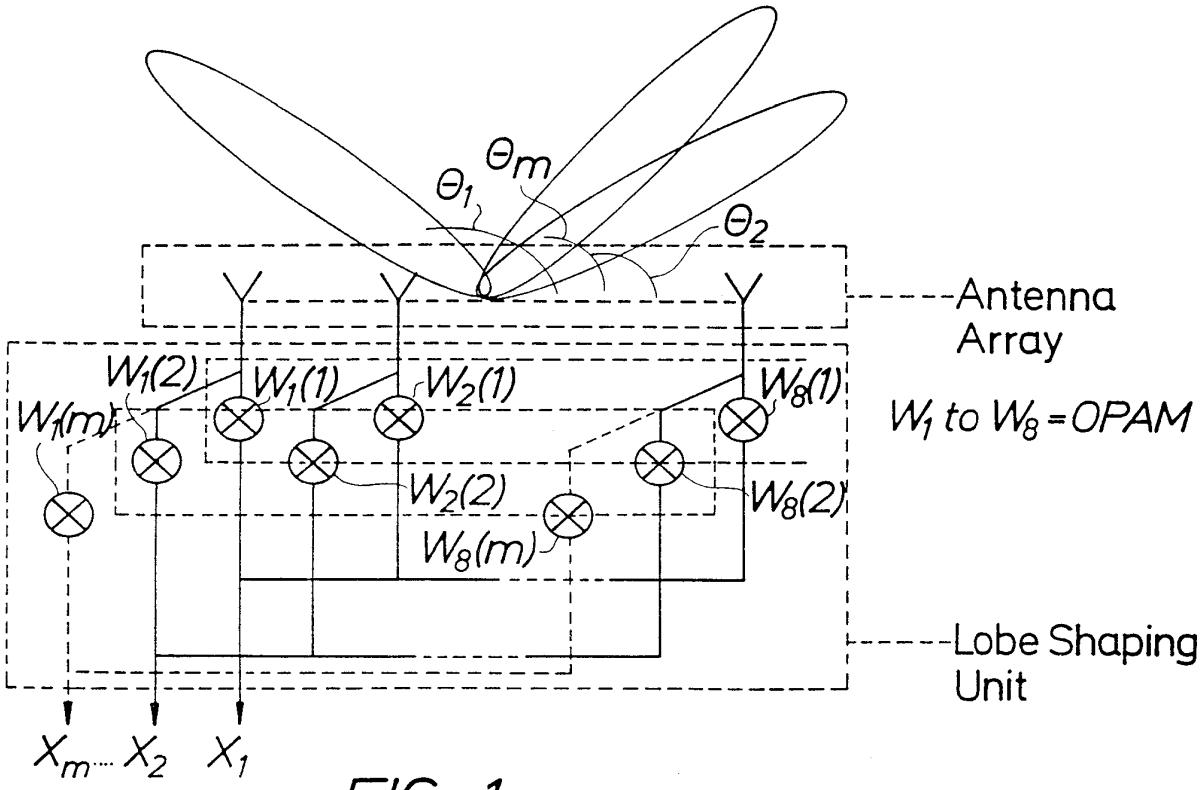
θm
θ1
θ2
Antenna Array
W1(2)
W1(1)
W2(1)
W8(1)
W1(m)
W1 to W8 = OPAM
W2(2)
W8(2)
W8(m)
Lobe Shaping Unit
Xm
X2
X1

FIG. 1

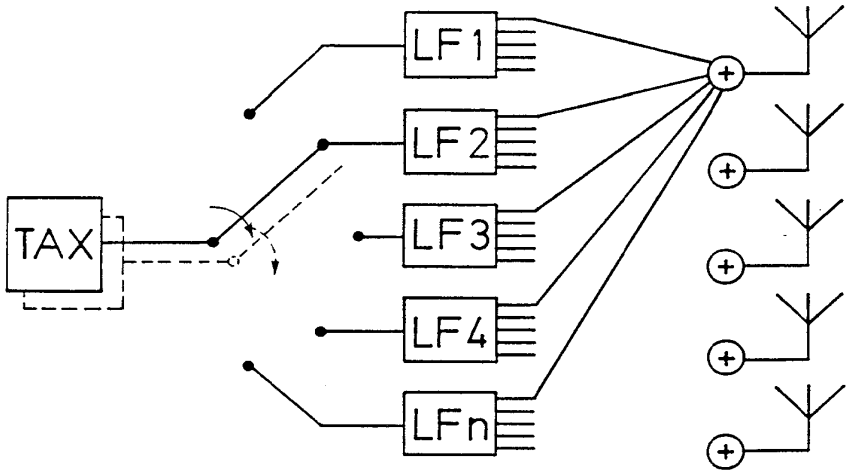
LF1
LF2
LF3
LF4
LFn
TAX

FIG. 2

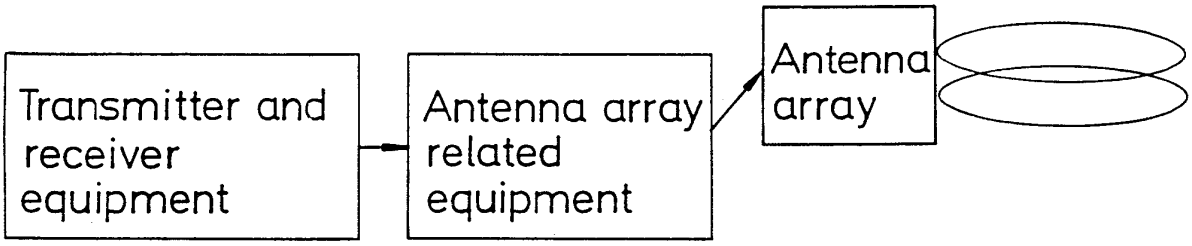
Transmitter and receiver equipment
Antenna array related equipment
Antenna array

FIG. 3

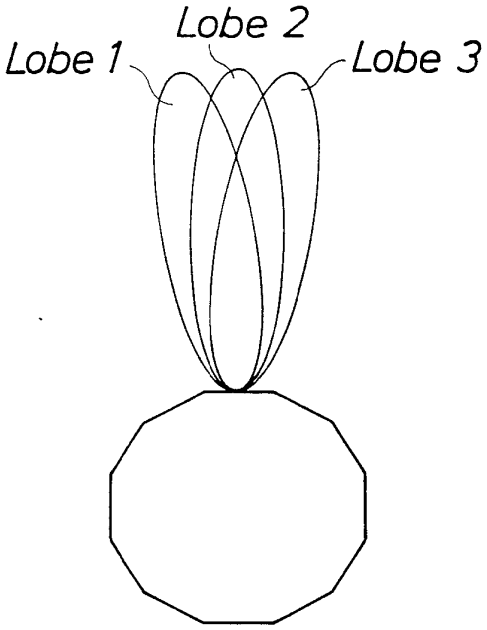
Lobe 1
Lobe 2
Lobe 3

FIG. 4

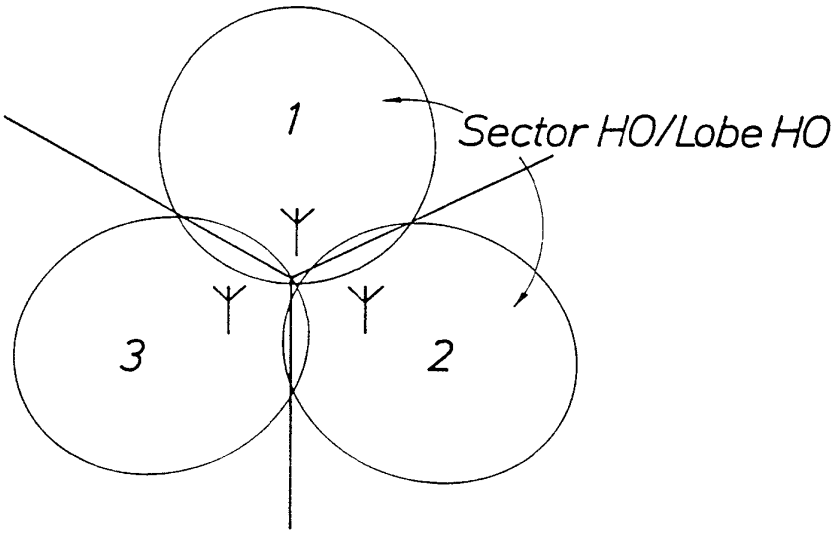

FIG. 5

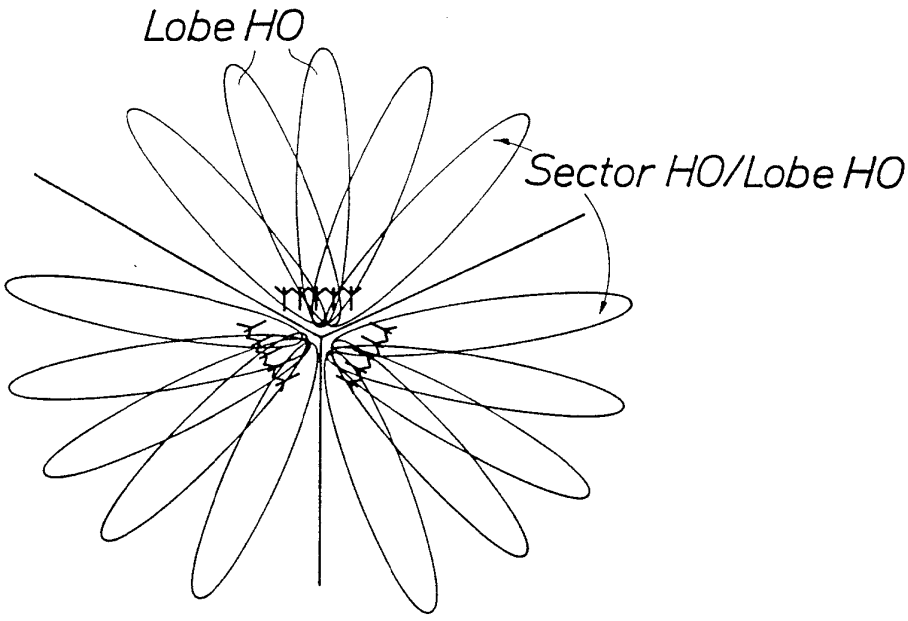

FIG. 6

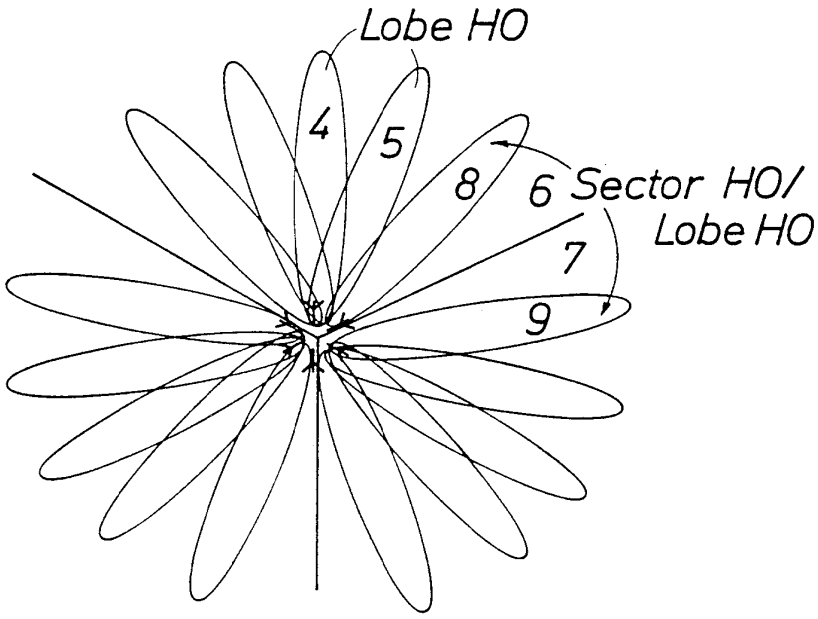

FIG. 7

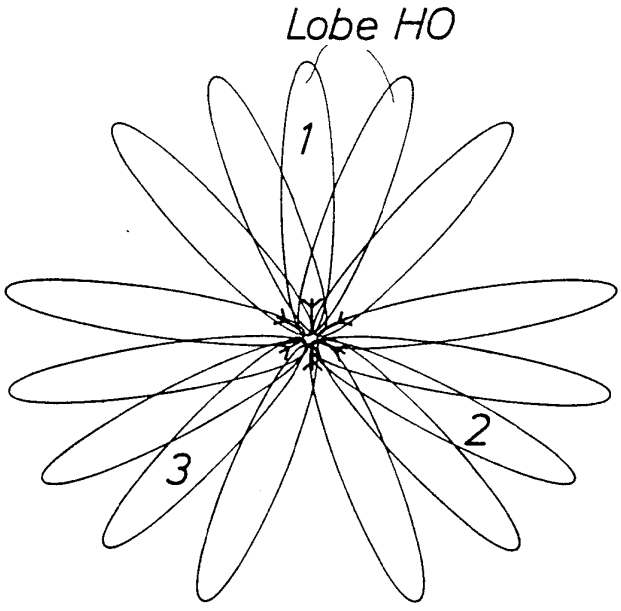

FIG. 8

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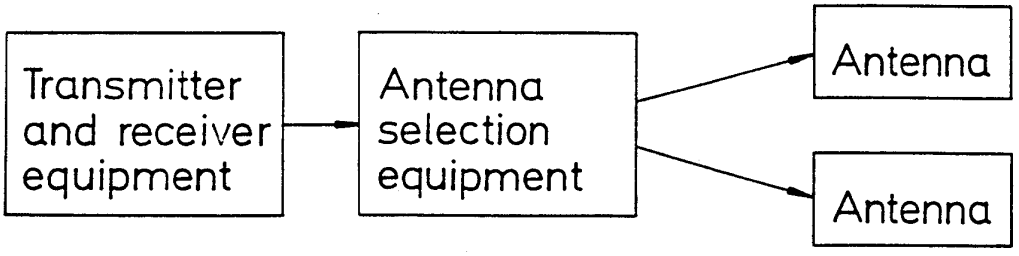

FIG. 9

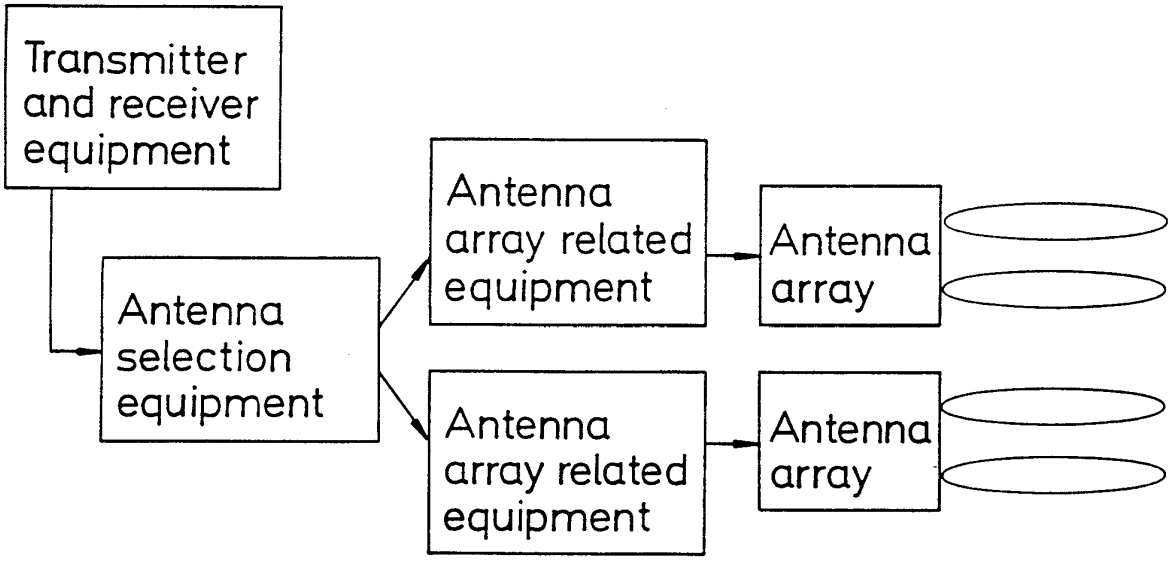

FIG. 10

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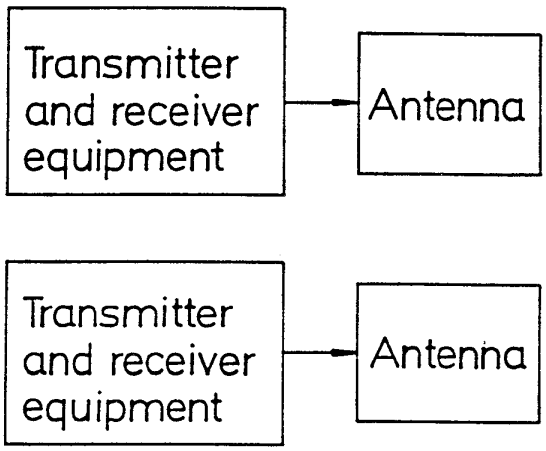
Transmitter and receiver equipment
Antenna
Transmitter and receiver equipment
Antenna

FIG. 11

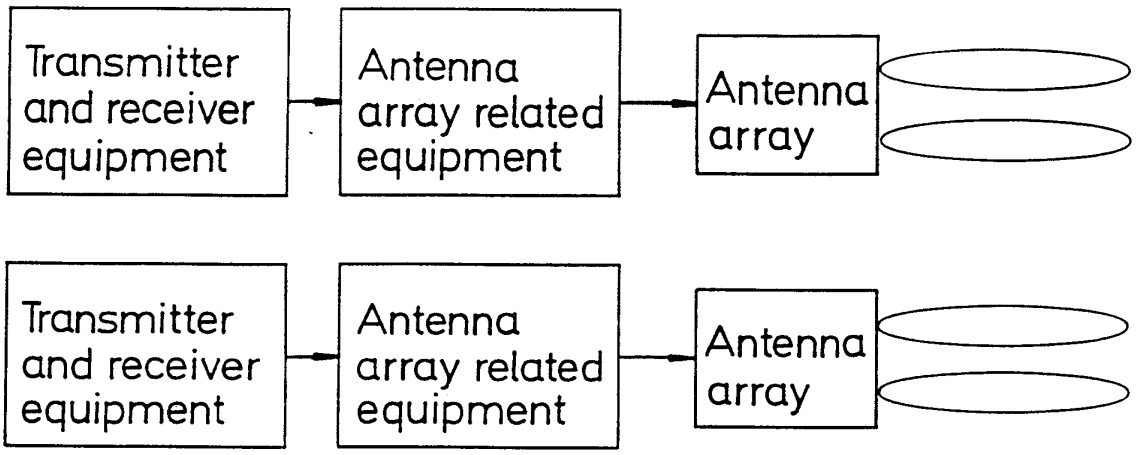
Transmitter and receiver equipment
Antenna array related equipment
Antenna array
Transmitter and receiver equipment
Antenna array related equipment
Antenna array

FIG. 12

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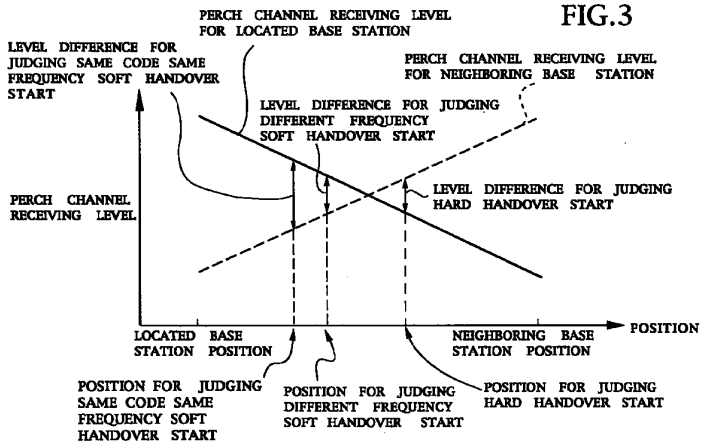
(54) Handover type judgement scheme for CDMA mobile communication system

(57) A handover type judgement scheme for a CDMA mobile communication system which is capable of judging an appropriate type of handover from multiple types of handover available. At the mobile station, one type of handover for which a handover start condition is weakest among available types of handover is judged. Then, whether the handover start condition for that one type of handover is satisfied or not is checked, and each base station for carrying out that one type of handover is notified when the handover start condition for said one type of handover is satisfied.

FIG.3



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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a handover type judgement scheme for a CDMA (Code Division Multiple Access) mobile communication system which is capable of carrying out any of multiple types of handover with different handover start conditions at a time of handover in which a mobile station moves from a currently communicating base station to another base station.

DESCRIPTION OF THE BACKGROUND ART

In the conventional mobile communication system such as PDC (Personal Digital Cellular) system that is currently providing the mobile communication service in Japan, there is only one available type of handover called hard handover.

In contrast, in the CDMA mobile communication system, the soft handover in also available in addition to the hard handover, and this soft handover further includes multiple types of soft handovers such as the same code same frequency soft handover and the different frequency soft handover. Here, these multiple types of handovers are associated with mutually different handover start conditions.

In order for each mobile station to carry out the handover properly, each base station is transmitting the perch channel (or the pilot channel). The mobile station receives the perch channel transmitted from each base station of each nearby cell, compares the receiving level of the perch channel received from each nearby cell with the receiving level of the perch channel of a currently located cell, and judges the start of the handover according to the obtained difference.

Here, as already mentioned above, the available types of handover includes the hard handover, the same code same frequency soft handover, and the different frequency soft handover, and the handover start conditions for these three types of handover are as indicated in Fig. 3. As can be seen from Fig. 3, when an influence on the radio channel capacity is taken into account, the handover start condition is weakest for the same code same frequency soft handover, second weakest for the different frequency soft handover, and strongest for the hard handover.

As already mentioned above, the conventional mobile communication system has been designed to use only one type of handover, so that there has been no means for Judging an appropriate type of handover to be executed out of multiple types of handover.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a handover type judgement scheme for a CDMA mobile communication system which is capable of judging an appropriate type of handover from multiple types of handover available.

According to one aspect of the present invention there is provided a handover type judgement method for a CDMA mobile communication system which is capable of carrying out any of multiple types of handover with different handover start conditions, the method comprising the steps of: judging one type of handover for which a handover start condition is weakest among available types of handover at a mobile station; and checking whether the handover start condition for said one type of handover is satisfied or not at the mobile station, and notifying each base station for carrying out said one type of handover when the handover start condition for said one type of handover is satisfied.

According to another aspect of the present invention there is provided a CDMA mobile communication system for carrying out any of multiple types of handover with different handover start conditions, comprising: a plurality of base stations; and at least one mobile station having: a judging unit for judging one type of handover for which a handover start condition is weakest among available types of handover; and a checking unit for checking whether the handover start condition for said one type of handover is satisfied or not, and notifying each base station for carrying out said one type of handover when the handover start condition for said one type of handover is satisfied.

According to another aspect of the present invention there is provided a mobile station apparatus for use as a mobile station in a CDMA mobile communication system for carrying out any of multiple types of handover with different handover start conditions, the apparatus comprising: a judging unit for judging one type of handover for which a handover start condition is weakest among available types of handover; and a checking unit for checking whether the handover start condition for said one type of handover is satisfied or not, and notifying each base station for carrying out said one type of handover when the handover start condition for said one type of handover is satisfied.

According to another aspect of the present invention there is provided a base station apparatus for use as a base station in a CDMA mobile communication system for carrying out any of multiple types of handover with different handover start conditions, the apparatus comprising: a measuring unit for measuring a radio channel state for each cell/sector of the base station; a determining unit for determining each impossible type of handover that cannot be carried out for each cell/sector by the base station according to the radio channel state measured by the measuring unit; and a notifying unit for notifying an information indicating said each impossible type of handover to a mobile station, so that at a time of handover with respect to the base station, the mobile station judges one type of handover for which a hando-

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ver start condition is weakest among available types of handover which include said multiple types of handover except for said each impossible type of handover according to said information, checks whether the handover start condition for said one type of handover is satisfied or not, and notifies each base station for carrying out said one type of handover when the handover start condition for said one type of handover is satisfied.

According to another aspect of the present invention there is provided a base station apparatus for use as a base station in a CDMA mobile communication system for carrying out any of multiple types of handover with different handover start conditions including a same code same frequency soft handover and a different frequency soft handover, the apparatus comprising: a measuring unit for measuring an interference receiving level or a total receiving level of each frequency bandwidth that is implemented at the base station for each cell/sector of the base station; and a notifying unit for notifying an information indicating that one frequency bandwidth cannot be used for one cell/sector to a mobile station, when a measured value for said one frequency bandwidth and said one cell/sector is greater than a prescribed threshold value, so that at a time of handover with respect to said one cell/sector while the mobile station is currently using said one frequency bandwidth as indicated by said information, the mobile station judges the different frequency soft handover as having a weakest handover start condition among available types of handover, checks whether the handover start condition for the different frequency soft handover is satisfied or not without checking the handover start condition for the same code same frequency soft handover with respect to said one cell/sector, and notifies each base station for carrying out the different frequency soft handover when the handover start condition for the different frequency soft handover is satisfied.

Other features and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a mobile station apparatus for realizing a handover type judgement scheme for a CDMA mobile communication system according to the present invention.

Fig. 2 is a block diagram of a base station apparatus for realizing a handover type Judgement scheme for a CDMA mobile communication system according to the present invention.

Fig. 3 is a graph for explaining handover start conditions for three types of handover used in a handover type judgement scheme for a CDMA mobile communication system according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Fig. 1 to Fig. 3, various embodiments of a handover type judgement scheme for a CDMA mobile communication system according to the present invention will be described in detail.

Fig. 1 and Fig. 2 respectively show a mobile station apparatus and a base station apparatus for realizing the handover type judgement scheme for a CDMA mobile communication system according to the present invention.

The mobile station apparatus of Fig. 1 has an antenna 1 for receiving radio signals from base stations and transmitting radio signals to base stations. The signals from base stations received by the antenna 1 are supplied to a demodulation unit 7 through a duplexer 3 and a reception unit 5, and applied with the despreading using a spread code and the usual demodulation at this demodulation unit 7. The demodulated signals are then supplied to a decoding unit 9 which decodes the demodulated signals into transmission signals and control signals. The decoded control signals are supplied to a control unit 11, while the decoded transmission signals are supplied to a man-machine interface (not shown).

On the other hand, transmission signals such as speech signals from the man-machine interface are supplied to an encoding unit 13 along with the control signals from control unit 11, encoded at this encoding unit 13, applied with the primary modulation and the spreading using a spread code at a modulation unit 15, and then transmitted to base stations from the antenna 1 through a transmission unit 17 and the duplexer 3.

In addition, the mobile station apparatus of Fig. 1 also has a memory 51 connected to the control unit 11, which stores different handover start conditions for multiple types of handover along with an order of weakness among these handover start conditions, where the multiple types of handover includes the same code same frequency soft handover, the different frequency soft handover, and the hard handover. The CDMA mobile communication system of this embodiment is capable of carrying out any of these multiple types of handover. In addition, the memory 51 is also capable of storing an unexecutable handover type which is to be notified from a base station as will be described in detail below.

Moreover, the mobile station apparatus of Fig. 1 also has a measurement unit 53 provided between the reception unit 5 and the control unit 11, which measures a total receiving level or an interference receiving level of a frequency bandwidth by which this mobile station is currently communicating with base stations, and supplies the measured value to the control unit 11.

The base station apparatus of Fig. 2 has an antenna 21 for receiving radio signals from mobile stations and transmitting radio signals to mobile stations. The signals from mobile stations received by the

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antenna 21 are supplied to a demodulation unit 27 through a duplexer 23 and a reception unit 25, and applied with the despreading using a spread code and the usual demodulation at this demodulation unit 27. The demodulated signals are then supplied to a decoding unit 29 which decodes the demodulated signals into transmission signals and control signals. The decoded control signals are supplied to a control unit 31, while the decoded transmission signals are transmitted to an upper level exchange station (not shown) through a wire transmission line transmission unit 39.

On the other hand, transmission signals the exchange station are received by a wire transmission line reception unit 41, and decomposed into the transmission signals and the control signals. The decomposed control signals are supplied to the control unit 31, while the decomposed transmission signals are encoded at an encoding unit 33, applied with the primary modulation and the spreading using a spread code at a modulation unit 15, and then transmitted to mobile stations from the antenna 21 through a transmission unit 7 and the duplexer 23.

Moreover, the base station apparatus of Fig. 2 also has a measurement unit 55 provided between the reception unit 25 and the control unit 31, which measures a radio channel state for each cell/sector, or a total receiving level or an interference receiving level of each frequency bandwidth implemented at this base station for each cell/sector, and supplies the measured value to the control unit 31.

In the mobile communication system having the mobile station device of Fig. 1 and the base station of Fig. 2 as described above, it is possible to carry out any of the multiple types of handover including the same code same frequency soft handover, the different frequency soft handover, and the hard handover, under different handover start conditions as indicated in Fig. 3.

Now, in one embodiment of a handover type judgement scheme according to the present invention, the mobile station judges and selects a handover type which has the weakest handover start condition among these multiple types of handover as the most effective one from a viewpoint of the radio channel capacity, and when the handover start condition for the selected handover type is satisfied, the mobile station notifies this fact to the base station so as to carry out the selected type of handover.

As can be seen from a level difference for judging the handover start for each handover type indicated in Fig. 3, the handover start condition is weakest for the same code same frequency soft handover, second weakest for the different frequency soft handover, and strongest for the hard handover among three types of handover available in this mobile communication system, and as already mentioned above, the memory 51 provided in the mobile station device stores these different handover start conditions for multiple types of handover along with an order of weakness among these handover start conditions.

At the mobile station, normally, whether the weakest handover start condition among the handover start conditions for multiple types of handover as stored in the memory 51, that is the handover start condition for the same code sane frequency soft handover, is satisfied or not is regularly checked by the control unit 11, and when this handover start condition is satisfied, this fact is notified from the control unit 11 to the base station in a form of a control signal which is transmitted through the encoding unit 13, the modulation unit 15, the transmission unit 17, and the duplexer 3, so as to start the same code same frequency soft handover.

In addition, there are cases in which a certain base station cannot use a particular frequency or cannot carry out the soft handover so that only the hard handover is possible, and when a particular type of handover cannot be carried out at a certain base station because of the reason not changing in time such as that related to the system configuration, this base station notifies this fact to the mobile station in advance. Then, the mobile station judges and selects a handover type which has the weakest handover start condition among the available types of handover excluding the notified type of handover that cannot be carried out at the base station, and when the handover start condition for the selected handover type is satisfied, the mobile station notifies this fact to the base station so as to carry out the selected type of handover.

As one concrete example of this embodiment, the base station notifies the available frequency bandwidth of each surrounding cell/sector to the mobile station in advance, and the mobile station stores this available frequency bandwidth of each surrounding cell/sector notified from the base station into the memory 51. Then, the mobile station identifies each cell/sector at which the same code same frequency soft handover cannot be carried out according to the stored available frequency bandwidth, and makes the judgement of the handover start condition for the different frequency soft handover with respect to each identified cell/sector, without making the judgement of the handover start condition for the same code same frequency soft handover. Then, when the handover start condition for the different frequency soft handover is satisfied, the mobile station notifies this fact to the base station.

As another concrete example of this embodiment, when a certain base station cannot carry out the soft handover so that only the hard handover is possible, this base station notifies this fact to the mobile station in advance, and the mobile station stores this notification into the memory 51. Then, according to this stored notification, the mobile station makes the judgement of the handover start condition for the hard handover with respect to this base station, without making the judgement of the handover start condition for the soft handover. Then, when the handover start condition for the hard handover is satisfied, the mobile station notifies

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this fact to this base station.

Next, in another embodiment of a handover type judgement scheme according to the present invention, the mobile station measures the downlink radio channel state at the measurement unit 53, and judges whether it is possible to carry out each type of handover or not at the control unit 11 according to the measured value, in order to cope with a case in which a particular type of handover cannot be carried out because of the reason changing in time, as in a case where the interference receiving level of the frequency bandwidth currently used for the communication at the mobile station is greater than a prescribed threshold level and the radio channel capacity of this frequency bandwidth is already full so that the same code same frequency soft handover using this frequency bandwidth cannot be carried out.

Then, the mobile station judges and selects a handover type which has the weakest handover start condition among the available types of handover excluding the type of handover that has been judged as not possible to carry out, and when the handover start condition for the selected handover type is satisfied, the mobile station notifies this fact to the base station so as to carry out the selected type of handover.

As one concrete example of this embodiment, the mobile station measures the interference receiving level or the total receiving level of the frequency bandwidth which is currently used for the communication at the measurement unit 53, and compares the measured value with a prescribed threshold value at the control unit 11. Then, when the measured value is greater than the prescribed threshold value, the mobile station makes the judgement of the handover start condition for the different frequency soft handover, without making the Judgement of the handover start condition for the same code same frequency soft handover using this frequency bandwidth, and when the handover start condition for the different frequency soft handover is satisfied, the mobile station notifies this fact to this base station.

Next, in another embodiment of a handover type judgement scheme according to the present invention, in order to cope with a case in which a particular type of handover cannot be carried out because of the reason changing in time such as the capacity overflow as described above, each base station measures the uplink radio channel state for each cell/sector at the measurement unit 55, judges whether it is possible to carry out each type of handover or not according to the measured value, and notifies an information on this judgement result to the surrounding base stations. Then, each surrounding base station notifies this information to the currently communicating mobile station.

Then, the mobile station judges and selects a handover type which has the weakest handover start condition among the available types of handover excluding the type of handover that has been judged as not possible to carry out with respect to a relevant cell/sector according to the notified information, and when the handover start condition for the selected handover type is satisfied, the mobile station notifies this fact to the base station so as to carry out the selected type of handover.

As one concrete example of this embodiment, each base station measures the interference receiving level or the total receiving level of each frequency bandwidth that is implemented at that base station, for each cell/sector at the measurement unit 55, and compares the measured value with a prescribed threshold value at the control unit 31. Then, when the measured value is greater than the prescribed threshold value, each mobile station notifies the fact that the frequency bandwidth corresponding to this measured value cannot be used to the surrounding base stations. Then, each surrounding base station notifies this notified frequency bandwidth that cannot be used to the currently communicating mobile station.

At the mobile station which received this notification and which is using this notified frequency bandwidth, the judgement of the handover start condition for the different frequency soft handover is made with respect to a relevant cell/sector, without making the judgement of the handover start condition for the same code same frequency soft handover using this frequency bandwidth, and when the handover start condition for the different frequency soft handover is satisfied, the mobile station notifies this fact to this base station.

Note here that the notification from the base station in this embodiment may be made only with respect to the mobile station which is currently using the relevant frequency bandwidth for the communication.

As described, according to the handover type Judgement scheme of the present invention, the mobile station judges and selects a handover type which has the weakest handover start condition among the available multiple types of handover, and when the handover start condition for the selected handover type is satisfied, this fact is notified to the base station so as to carry out the selected type of handover. Consequently, the each type of handover among the available multiple types of handover can be carried out appropriately according to its handover start condition.

In addition, in a case where a particular type of handover cannot be carried out because of either the reason not changing in time such as that related to the system configuration or the reason changing in time such as the capacity overflow, this fact is notified in advance or such a case is detected. Then, the mobile station judges and selects a handover type which has the weakest handover start condition among the available types of handover excluding this particular type of handover that cannot be carried out, and when the handover start condition for the selected handover type is satisfied, this fact is notified to the base station so as to carry out the selected type of handover. Conse-

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quently, it is possible to realize an efficient handover type judgement scheme by eliminating an unnecessary judgement of the handover start condition for that particular type of handover that cannot be carried out as well as an unnecessary increase of the traffic due to the notification resulting from such an unnecessary judgement.

It is to be noted that, besides those already mentioned above, many modifications and variations of the above embodiments may be made without departing from the novel and advantageous features of the present invention. Accordingly, all such modifications and variations are intended to be included within the scope of the appended claims.

Claims

1. A handover type judgement method for a CDMA mobile communication system which is capable of carrying out any of multiple types of handover with different handover start conditions, the method comprising the steps of:

   judging one type of handover for which a handover start condition is weakest among available types of handover at a mobile station; and
   checking whether the handover start condition for said one type of handover is satisfied or not at the mobile station, and notifying each base station for carrying out said one type of handover when the handover start condition for said one type of handover is satisfied.

2. The method of claim 1, further comprising the step of:

   notifying from one base station to the mobile station in advance a particular type of handover among said multiple types of handover that cannot be carried out at said one base station;
   wherein at a time of handover with respect to said one base station, the judging step judges said one type of handover from said available types of handover which include said multiple types of handover except for said particular type of handover.

3. The method of claim 1, further comprising the steps of:

   notifying from one base station to the mobile station in advance an available frequency bandwidth for each surrounding cell/sector of said one base station; and
   determining one cell/sector for which a same code same frequency soft handover cannot be carried out according to the available frequency bandwidth for said one cell/sector as notified by the notifying step;
   wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and at a time of handover with respect to said one cell/sector determined by the determining step, the judging step judges the different frequency soft handover as said one type of handover so that the checking step does not check the handover start condition for the same code same frequency soft handover with respect to said one cell/sector.

4. The method of claim 1, further comprising the steps of:

   notifying from one base station to the mobile station in advance an information as to whether a soft handover is possible or not with respect to each surrounding cell/sector of said one base station; and
   determining one cell/sector for which the soft handover is not possible according to the information for said one cell/sector as notified by the notifying step;
   wherein said multiple types of handover includes a soft handover and a hard handover, and at a time of handover with respect to said one cell/sector determined by the determining step, the judging step judges the hard handover as said one type of handover so that the checking step does not check the handover start condition for the soft handover with respect to said one cell/sector.

5. The method of claim 1, further comprising the steps of:

   measuring a radio channel state at the mobile station; and
   determining each impossible type of handover that cannot be carried out by the mobile station according to the radio channel state measured by the measuring step;
   wherein the judging step judges said one type of handover from said available types of handover which include said multiple types of handover except for said each impossible type of handover.

6. The method of claim 1, further comprising the step of:

   measuring an interference receiving level or a total receiving level of a frequency bandwidth currently used for communication at the mobile station;

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wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and when a measured value obtained by the measuring step is greater than a prescribed threshold value, the judging step judges the different frequency soft handover as said one type of handover so that the checking step does not check the handover start condition for the same code same frequency soft handover.

7. The method of claim 1, further comprising the steps of:

measuring a radio channel state for each cell/sector of each base station;
determining each impossible type of handover that cannot be carried out for each cell/sector by said each base station according to the radio channel state measured by the measuring step; and
notifying an information indicating said each impossible type of handover from said each base station to the mobile station;

wherein at a time of handover with respect to said each base station, the judging step judges said one type of handover from said available types of handover which include said multiple types of handover except for said each impossible type of handover according to said information.

8. The method of claim 7, wherein at the notifying step, said each base station notifies said information to surrounding base stations and the mobile station receives said information via one of said surrounding base stations with which the mobile station is currently communicating.

9. The method of claim 1, further comprising the steps of:

measuring an interference receiving level or a total receiving level of each frequency bandwidth that is implemented at each base station for each cell/sector of said each base station; and
notifying an information indicating that one frequency bandwidth cannot be used for one cell/sector from said each base station to the mobile station, when a measured value for said one frequency bandwidth and said one cell/sector is greater than a prescribed threshold value;

wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and at a time of handover with respect to said one cell/sector while the mobile station is currently using said one frequency bandwidth as indicated by said information, the judging step judges the different frequency soft handover as said one type of handover so that the checking step does not check the handover start condition for the same code same frequency soft handover with respect to said one cell/sector.

10. The method of claim 9, wherein at the notifying step, said each base station notifies said information to surrounding base stations and the mobile station receives said information via one of said surrounding base stations with which the mobile station is currently communicating.

11. A CDMA mobile communication system for carrying out any of multiple types of handover with different handover start conditions, comprising:

a plurality of base stations; and
at least one mobile station having:

a judging unit for judging one type of handover for which a handover start condition is weakest among available types of handover; and
a checking unit for checking whether the handover start condition for said one type of handover is satisfied or not, and notifying each base station for carrying out said one type of handover when the handover start condition for said one type of handover is satisfied.

12. The system of claim 11, wherein one base station has a notifying unit for notifying to the mobile station in advance a particular type of handover among said multiple types of handover that cannot be carried out at said one base station; and

wherein at a time of handover with respect to said one base station, the judging unit judges said one type of handover from said available types of handover which include said multiple types of handover except for said particular type of handover.

13. The system of claim 11, wherein one base station has a notifying unit for notifying to the mobile station in advance an available frequency bandwidth for each surrounding cell/sector of said one base station;

the mobile station also has a determining unit for determining one cell/sector for which a same code same frequency soft handover cannot be carried out according to the available

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frequency bandwidth for said one cell/sector as notified by the notifying unit; and

wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and at a time of handover with respect to said one cell/sector determined by the determining unit, the judging unit judges the different frequency soft handover as said one type of handover so that the checking unit does not check the handover start condition for the same code same frequency soft handover with respect to said one cell/sector.

14. The system of claim 11, wherein one base station has a notifying unit for notifying to the mobile station in advance an information as to whether a soft handover is possible or not with respect to each surrounding cell/sector of said one base station;

the mobile station also has a determining unit for determining one cell/sector for which the soft handover is not possible according to the information for said one cell/sector as notified by the notifying unit; and

wherein said multiple types of handover includes a soft handover and a hard handover, and at a time of handover with respect to said one cell/sector determined by the determining unit, the judging unit judges the hard handover as said one type of handover so that the checking unit does not check the handover start condition for the soft handover with respect to said one cell/sector.

15. The system of claim 11, wherein the mobile station also has:

a measuring unit for measuring a radio channel state; and
a determining unit for determining each impossible type of handover that cannot be carried out by the mobile station according to the radio channel state measured by the measuring unit; and

wherein the judging unit judges said one type of handover from said available types of handover which include said multiple types of handover except for said each impossible type of handover.

16. The system of claim 11, wherein the mobile station also has:

a measuring unit for measuring an interference receiving level or a total receiving level of a frequency bandwidth currently used for communication; and

wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and when a measured value obtained by the measuring unit is greater than a prescribed threshold value, the judging unit judges the different frequency soft handover as said one type of handover so that the checking unit does not check the handover start condition for the same code same frequency soft handover.

17. The system of claim 11, wherein each base station has:

a measuring unit for measuring a radio channel state for each cell/sector of said each base station;
a determining unit for determining each impossible type of handover that cannot be carried out for each cell/sector by said each base station according to the radio channel state measured by the measuring unit; and
a notifying unit for notifying an information indicating said each impossible type of handover to the mobile station; and

wherein at a time of handover with respect to said each base station, the judging unit judges said one type of handover from said available types of handover which include said multiple types of handover except for said each impossible type of handover according to said information.

18. The system of claim 17, wherein the notifying unit notifies said information to surrounding base stations and the mobile station receives said information via one of said surrounding base stations with which the mobile station is currently communicating.

19. The system of claim 11, wherein each base station has:

a measuring unit for measuring an interference receiving level or a total receiving level of each frequency bandwidth that is implemented at said each base station for each cell/sector of said each base station; and
a notifying unit for notifying an information indicating that one frequency bandwidth cannot be used for one cell/sector to the mobile station, when a measured value for said one frequency bandwidth and said one cell/sector is greater than a prescribed threshold value; and

wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and at a time of handover with respect to

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said one cell/sector while the mobile station is currently using said one frequency bandwidth as indicated by said information, the judging unit judges the different frequency soft handover as said one type of handover so that the checking unit does not check the handover start condition for the same code same frequency soft handover with respect to said one cell/sector.

20. The system of claim 19, wherein the notifying unit notifies said information to surrounding base stations and the mobile station receives said information via one of said surrounding base stations with which the mobile station is currently communicating.

21. A mobile station apparatus for use as a mobile station in a CDMA mobile communication system for carrying out any of multiple types of handover with different handover start conditions, the apparatus comprising:

a judging unit for judging one type of handover for which a handover start condition is weakest among available types of handover; and

a checking unit for checking whether the handover start condition for said one type of handover is satisfied or not, and notifying each base station for carrying out said one type of handover when the handover start condition for said one type of handover is satisfied.

22. The apparatus of claim 21, wherein at a time of handover with respect to one base station, the judging unit receives in advance a particular type of handover among said multiple types of handover that cannot be carried out at said one base station, and the judging unit judges said one type of handover from said available types of handover which include said multiple types of handover except for said particular type of handover.

23. The apparatus of claim 21, further comprising:

a determining unit for receiving from one base station in advance an available frequency bandwidth for each surrounding cell/sector of said one base station, and determining one cell/sector for which a same code same frequency soft handover cannot be carried out according to the available frequency bandwidth for said one cell/sector as notified from said one base station;

wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and at a time of handover with respect to said one cell/sector determined by the determining unit, the judging unit judges the different frequency soft handover as said one type of handover so that the checking unit does not check the handover start condition for the same code same frequency soft handover with respect to said one cell/sector.

24. The apparatus of claim 21, further comprising:

a determining unit for receiving from one base station in advance an information as to whether a soft handover is possible or not with respect to each surrounding cell/sector of said one base station, and determining one cell/sector for which the soft handover is not possible according to the information for said one cell/sector as notified from said one base station; and

wherein said multiple types of handover includes a soft handover and a hard handover, and at a time of handover with respect to said one cell/sector determined by the determining unit, the judging unit judges the hard handover as said one type of handover so that the checking unit does not check the handover start condition for the soft handover with respect to said one cell/sector.

25. The apparatus of claim 21, further comprising:

a measuring unit for measuring a radio channel state; and

a determining unit for determining each impossible type of handover that cannot be carried out according to the radio channel state measured by the measuring unit; and

wherein the judging unit judges said one type of handover from said available types of handover which include said multiple types of handover except for said each impossible type of handover.

26. The apparatus of claim 21, further comprising:

a measuring unit for measuring an interference receiving level or a total receiving level of a frequency bandwidth currently used for communication; and

wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and when a measured value obtained by the measuring unit is greater than a prescribed threshold value, the judging unit judges the different frequency soft handover as said one type of handover so that the checking unit does not check the handover start condition for the

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same code same frequency soft handover.

27. The apparatus of claim 21, wherein each base station measures a radio channel state for each cell/sector of said each base station, determines each impossible type of handover that cannot be carried out for each cell/sector by said each base station according to the radio channel state measured by said each base station, and notifies an information indicating said each impossible type of handover to the mobile station; and

wherein at a time of handover with respect to said each base station, the judging unit receives said information and judges said one type of handover from said available types of handover which include said multiple types of handover except for said each impossible type of handover according to said information.

28. The apparatus of claim 27, wherein said each base station notifies said information to surrounding base stations and the judging unit receives said information via one of said surrounding base stations with which the mobile station is currently communicating.

29. The apparatus of claim 21, wherein each base station measures an interference receiving level or a total receiving level of each frequency bandwidth that is implemented at said each base station for each cell/sector of said each base station, and notifies an information indicating that one frequency bandwidth cannot be used for one cell/sector to the mobile station, when a measured value for said one frequency bandwidth and said one cell/sector is greater than a prescribed threshold value; and

wherein said multiple types of handover includes a same code same frequency soft handover and a different frequency soft handover, and at a time of handover with respect to said one cell/sector while the mobile station is currently using said one frequency bandwidth as indicated by said information, the judging unit receives said information and judges the different frequency soft handover as said one type of handover so that the checking unit does not check the handover start condition for the same code same frequency soft handover with respect to said one cell/sector.

30. The apparatus of claim 29, wherein said each base station notifies said information to surrounding base stations and the judging unit receives said information via one of said surrounding base stations with which the mobile station is currently communicating.

31. The apparatus of claim 21, further comprising:

a memory for storing the handover start conditions of said multiple types of handover;

wherein the judging unit judges said one type of handover according to the handover start conditions stored in the memory.

32. The apparatus of claim 31, wherein the memory also stores an order of weakness of the handover start conditions among said multiple types of handover.

33. A base station apparatus for use as a base station in a CDMA mobile communication system for carrying out any of multiple types of handover with different handover start conditions, the apparatus comprising:

a measuring unit for measuring a radio channel state for each cell/sector of the base station;

a determining unit for determining each impossible type of handover that cannot be carried out for each cell/sector by the base station according to the radio channel state measured by the measuring unit; and

a notifying unit for notifying an information indicating said each impossible type of handover to a mobile station, so that at a time of handover with respect to the base station, the mobile station judges one type of handover for which a handover start condition is weakest among available types of handover which include said multiple types of handover except for said each impossible type of handover according to said information, checks whether the handover start condition for said one type of handover is satisfied or not, and notifies each base station for carrying out said one type of handover when the handover start condition for said one type of handover is satisfied.

34. The apparatus of claim 33, wherein the notifying unit notifies said information to surrounding base stations and the mobile station receives said information via one of said surrounding base stations with which the mobile station is currently communicating.

35. A base station apparatus for use as a base station in a CDMA mobile communication system for carrying out any of multiple types of handover with different handover start conditions including a same code same frequency soft handover and a different frequency soft handover, the apparatus comprising:

a measuring unit for measuring an interference receiving level or a total receiving level of each frequency bandwidth that is implemented at the base station for each cell/sector of the base

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station; and

a notifying unit for notifying an information indicating that one frequency bandwidth cannot be used for one cell/sector to a mobile station, when a measured value for said one frequency bandwidth and said one cell/sector is greater than a prescribed threshold value, so that at a time of handover with respect to said one cell/sector while the mobile station is currently using said one frequency bandwidth as indicated by said information, the mobile station judges the different frequency soft handover as having a weakest handover start condition among available types of handover, checks whether the handover start condition for the different frequency soft handover is satisfied or not without checking the handover start condition for the same code same frequency soft handover with respect to said one cell/sector, and notifies each base station for carrying out the different frequency soft handover when the handover start condition for the different frequency soft handover is satisfied.

36. The apparatus of claim 35, wherein the notifying unit notifies said information to surrounding base stations and the mobile station receives said information via one of said surrounding base stations with which the mobile station is currently communicating.

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FIG.1

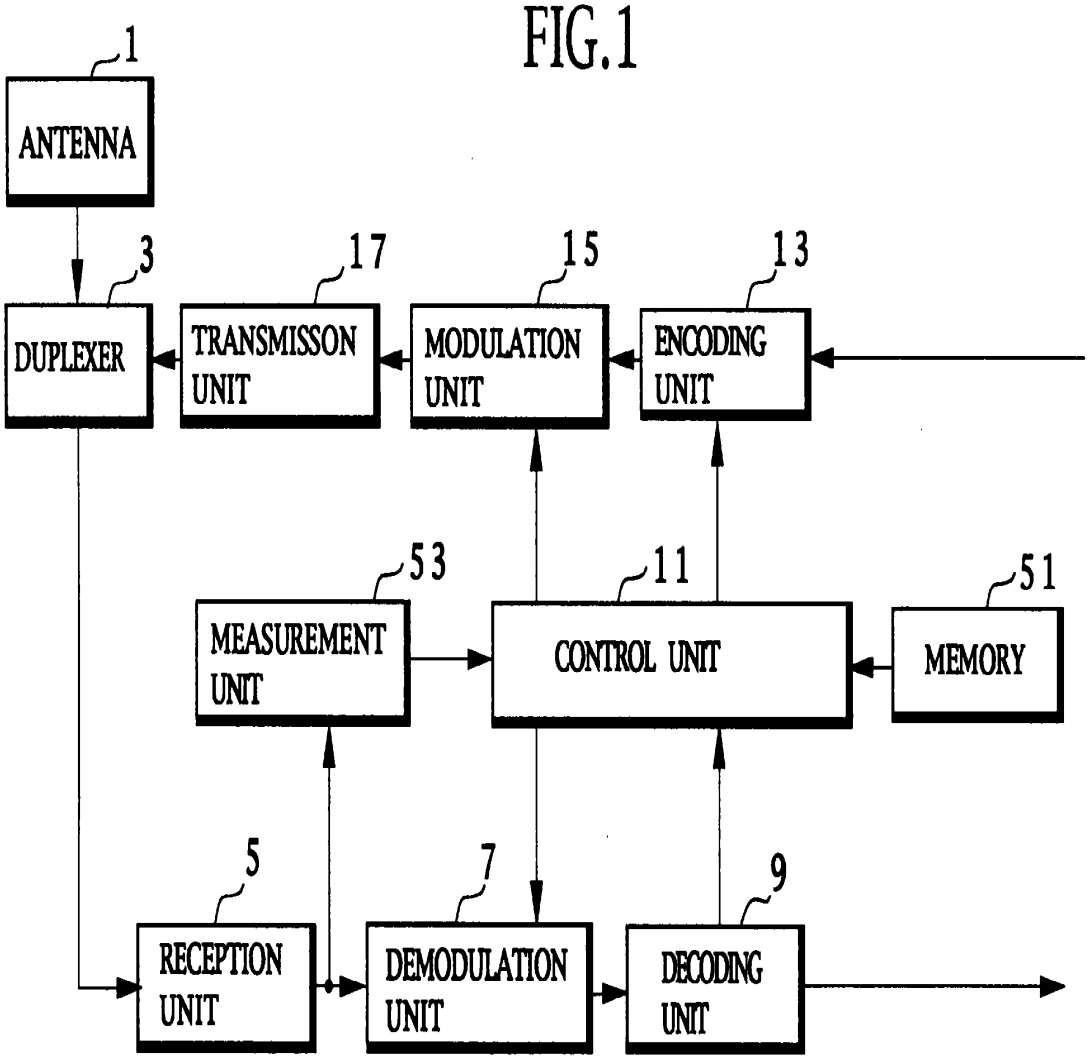

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FIG.2

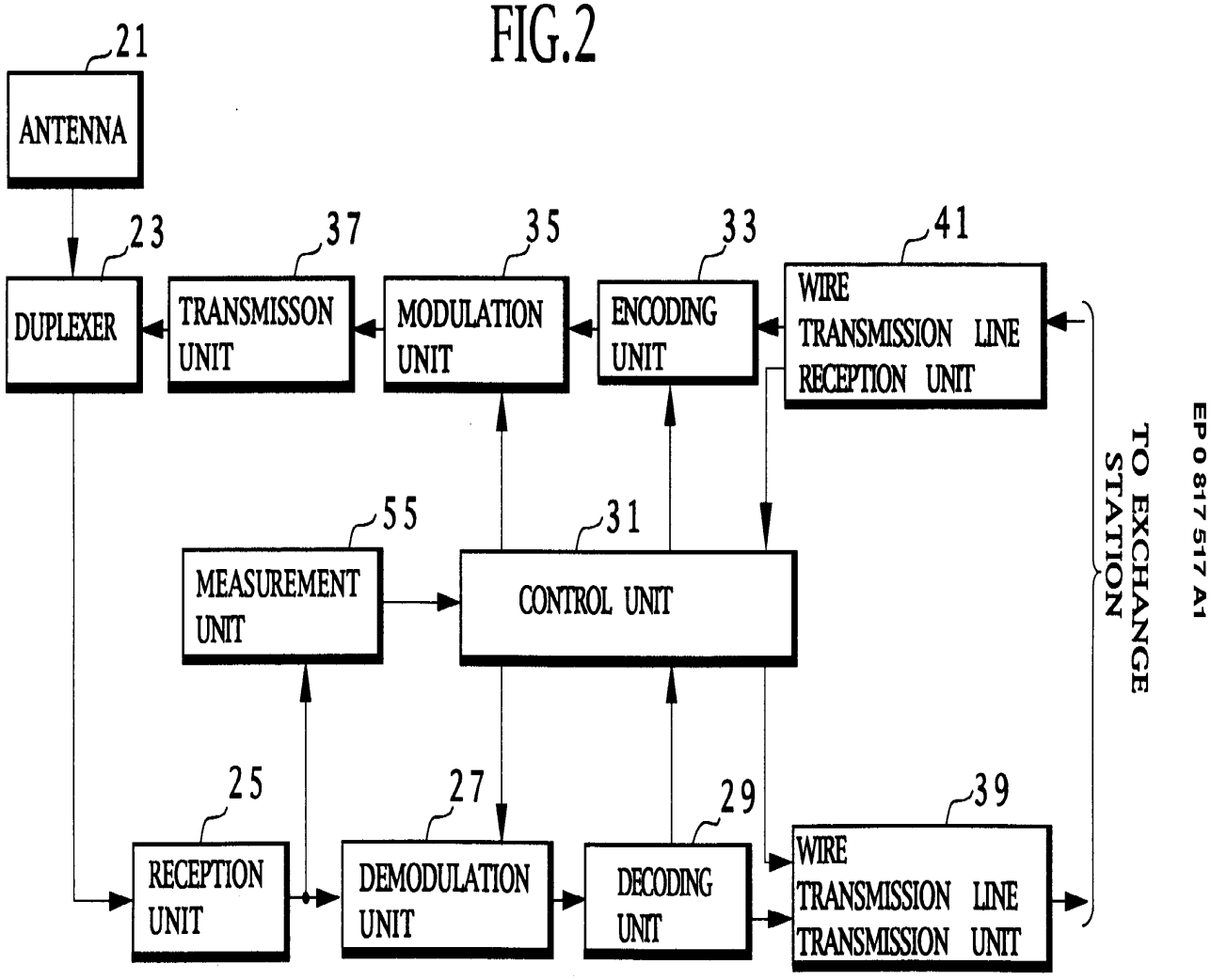

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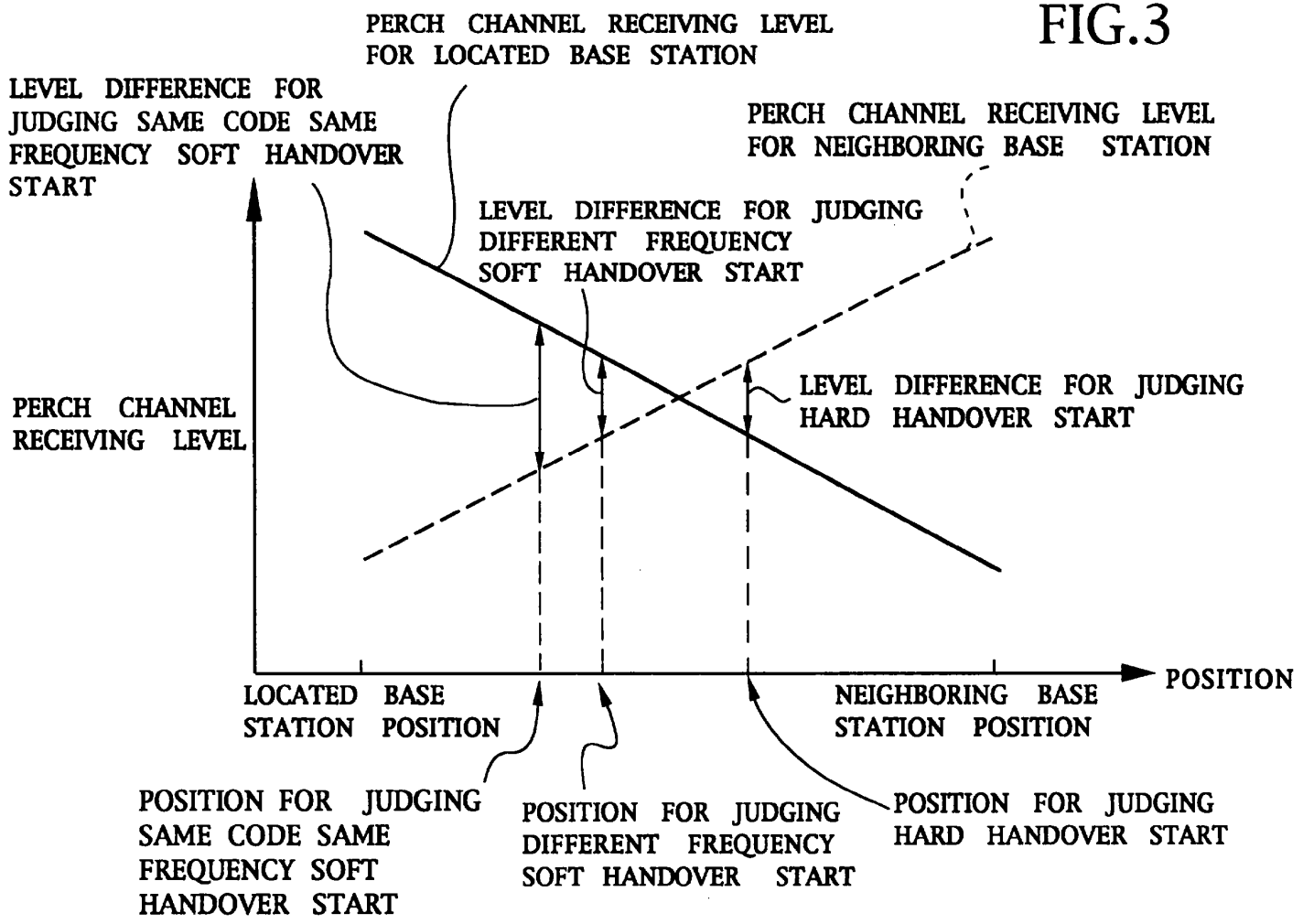
FIG.3



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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 11 0306

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 5 257 402 A (CRISLER KENNETH J) 26 October 1993	1,5,11, 15,21, 25,33	H04Q7/38 H04B7/26
A	* column 6, line 6 - column 6, line 60; figures 4,5 *	35	
A	WO 95 16329 A (MOTOROLA INC) 15 June 1995 * page 1, line 21 - page 2, line 36 * * page 4, line 23 - page 4, line 35 * * page 7, line 9 - page 7, line 21 *	1,4-6, 11, 14-19, 21, 24-29, 33,35	
A	WO 96 02117 A (NOKIA TELECOMMUNICATIONS OY ;JOLMA PETRI (FI)) 25 January 1996 * page 3, line 17 - page 5, line 14 *	1,4,11, 14,21, 24,33	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H04Q
H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	30 September 1997	Burghardt, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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Electronic Patent Application Fee Transmittal

Application Number:	15486245
Filing Date:	12-Apr-2017
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Filer:	Glen L. Nuttall/Mariel Boyan
Attorney Docket Number:	XRCOM.001C3

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	2806	1	90	90
		Total in USD ($)		**90**

Electronic Acknowledgement Receipt	
EFS ID:	31073977
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	20995
Filer:	Glen L. Nuttall/Mariel Boyan
Filer Authorized By:	Glen L. Nuttall
Attorney Docket Number:	XRCOM.001C3
Receipt Date:	29-NOV-2017
Filing Date:	12-APR-2017
Time Stamp:	13:05:23
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$90
RAM confirmation Number	112917INTEFSW13064800
Deposit Account	111159
Authorized User	Mariel Boyan
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.21 (Miscellaneous fees and charges)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		1640-001-201--IDSAsFiled11292017.pdf	1179915 9fb5cd5f8cabcd6260cb6a562207085b0329131d	yes	11
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Information Disclosure Statement (IDS) Form (SB08)		4	11	
	Transmittal Letter		1	3	
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9	Foreign Reference	WO9733388A1-00002237.pdf	2398811 7b8680d454139f189363ea58f8e0804dd8f6edc6	no	53
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14	Non Patent Literature	DEFS-VIVATO-00000001.pdf	9435230 196f8103b3ae3397ab5b56c641b1758dfa3000c8	no	96
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56	Non Patent Literature	DEFS-VIVATO-00000799.pdf	212508 c37779e9f8ad965f484d6717271c159f68c6eb57	no	2
Warnings:					
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		Total Files Size (in bytes):	105971637		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Acknowledgement Receipt

EFS ID:	31074547
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	20995
Filer:	Glen L. Nuttall/Mariel Boyan
Filer Authorized By:	Glen L. Nuttall
Attorney Docket Number:	XRCOM.001C3
Receipt Date:	29-NOV-2017
Filing Date:	12-APR-2017
Time Stamp:	15:01:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	DEFS-VIVATO-00000811.pdf	229324 d7db5c5770eb24f60801032aa02cd91d05aa817e	no	2

Warnings:

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2	Non Patent Literature	DEFS-VIVATO-00000813.pdf	435551 a9505106d5cf283fc2952490e3422d880ddd3e8f	no	4
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3	Non Patent Literature	DEFS-VIVATO-00000817.pdf	87859 6f2a9b02ba0529a88fbd199c9b54ae15878b15f4	no	1
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4	Non Patent Literature	DEFS-VIVATO-00000818.pdf	188729 6a639972e983982616 4ecf0a423a3fe2e91fe355	no	2
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5	Non Patent Literature	DEFS-VIVATO-00000820.pdf	101499 7aaf3cf85ed87948946fcc6e7cbaed05c3689cc5	no	1
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Acknowledgement Receipt

EFS ID:	31077953
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	20995
Filer:	Glen L. Nuttall/Mariel Boyan
Filer Authorized By:	Glen L. Nuttall
Attorney Docket Number:	XRCOM.001C3
Receipt Date:	29-NOV-2017
Filing Date:	12-APR-2017
Time Stamp:	15:42:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	ExC20-US6795409.pdf	1644859 6cd7c5cf45b15b127f009014a85df27622c8c1ce	no	53

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2	Non Patent Literature	ExC21-USPatentAppPub2001_0033600A1-Yang.pdf	1822443 39b8f2063a2754648e96bfa6075cdda095bebbba	no	57
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3	Non Patent Literature	ExC22-WO0038455.pdf	926936 ef7f31d8110f95bcbe3c487ccb3d3b684b0aa7eb	no	22
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4	Non Patent Literature	ExC23-PCTWO9921391Publication-Andersson.pdf	925519 3a1932a0f0e99537e4e42628cea5992de6a574b3	no	28
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5	Non Patent Literature	ExC24-US7062294.pdf	1432401 e6bf773b25c88cd9ad5992bfeeb1abf2d57d3274	no	45
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6	Non Patent Literature	ExC25-728PatentInvalidityChart-Marikar.pdf	536786 73b1c7898e9510ce8ea2b5b744bdc9b3b7bfed3b	no	17
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Warnings:					
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		Total Files Size (in bytes):	8401225		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Acknowledgement Receipt

EFS ID:	31077826
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	20995
Filer:	Glen L. Nuttall/Mariel Boyan
Filer Authorized By:	Glen L. Nuttall
Attorney Docket Number:	XRCOM.001C3
Receipt Date:	29-NOV-2017
Filing Date:	12-APR-2017
Time Stamp:	15:37:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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8	Non Patent Literature	ExA24-CapacityImprovementOfBase-station.pdf	353248 6d9f80f88a489b34b6760ae974e2b068043e5c26	no	12
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9	Non Patent Literature	ExA25-AdaptiveAntennaTransmission.pdf	507605 5a4ff2cf356e25c2a7f72a721ba4c44e9249d147	no	17
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10	Non Patent Literature	ExA26-AnOverviewOfSmartAntennaTechnology.pdf	2157561 a2d1fd2b2e43ade2c75a3f95360f6e5b16fb8947	no	75
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11	Non Patent Literature	ExA27-SmartAntennasForBattlefield.pdf	1663833 cde7aae947bb2c81e0866a6bc3a46c1efeafe0a6	no	69
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12	Non Patent Literature	ExA28-231ClaimChart-ExperimentalStudies.pdf	2971865 c876ab148d6b67319eee253332b60b95b1e070fa	no	86
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13	Non Patent Literature	ExA29-231PatentInvalidityChart-Gerlach93.pdf	860009 c810721ce982faa161bec220bd2e0ef02a717524	no	33
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14	Non Patent Literature	ExA30-231ClaimChart-ArrayCommIntellicell.pdf	1904040 9befded76842120e8aed4434d74d995bf8f6e5ce	no	48
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15	Non Patent Literature	ExB1-US5095531.pdf	3280056 1f27105050754c31aaa01937ed2df27b06f23c1e	no	107
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16	Non Patent Literature	ExB2-US5602555.pdf	875265 32f3dbfdac34d957a0d351682b3fd6edaabc973d	no	32
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17	Non Patent Literature	ExB3-US5603089.pdf	718222 8c82cdf19c4255ca93bc191d17a491ea3cf5ac37	no	27
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18	Non Patent Literature	ExB4-US5649293.pdf	778153 8437fd85e773a4e812416046cf91d7963f9ad8fc	no	25
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20	Non Patent Literature	ExB6-US5890067.pdf	1107132 8783dee8d097409754587c96ffac62714262e1d9	no	31
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21	Non Patent Literature	ExB7-US5966094.pdf	1188833 b81ede31a5204a3d8760c64ff4919611650a43d5	no	30
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22	Non Patent Literature	ExB8-US6233466.pdf	1937123 949352d250d94fc62d9f3a64b2669f8ec0c0c64d	no	59
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23	Non Patent Literature	ExB9-US6345188.pdf	2397254 3f79cea89947405ddb9f44c1d26d1fe913e4ea5d	no	92
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24	Non Patent Literature	ExB10-US6667712.pdf	1678187 a282287436ec40ccd5bbbbaf3ad8666f42fc06e3	no	54
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25	Non Patent Literature	ExB11-US6687492.pdf	1448881 a9bb15968c0b8f43cf2df2bb5d694483a693762d	no	49
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26	Non Patent Literature	ExB12-US6694154.pdf	1901139 ab982462d6329efec5d801255ef4c2380df8fa8d	no	51
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27	Non Patent Literature	ExB13-20020034967.pdf	2041338 a70f5d9c140f6288b756d402aa37c16ec2fc6e6f	no	62
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28	Non Patent Literature	ExB14-US6850741.pdf	2963064 7ace54faff66ebce92d2dbc098cd95fe4c354714	no	106
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29	Non Patent Literature	ExB15-US7031336.pdf	1141653 c4f1608e6c2bfb28806697ceee8839ab222cf8a8	no	38
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Information:					

30	Non Patent Literature	ExB16-US7054662.pdf	2721277 90e1fb178133a857a41f7f7d8b12fc7493f7dec5	no	118
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31	Non Patent Literature	ExB17-US7289826.pdf	2558881 a52895b5edd4a40d3e41c15438d9c777484 3f685	no	54
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32	Non Patent Literature	ExB18-US7346365.pdf	2603384 ee5f08eb9b5fa550330c87b927a3d5c0b5a 6810c	no	55
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33	Non Patent Literature	ExB19-US0030017853.pdf	1632663 4caebb112de291f12ada1e34cb5b997d944 7277f	no	50
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Information:					
34	Non Patent Literature	ExB20-US6795409.pdf	2620348 89bc95d2615c8e513a3276bccea162d7715 66ba5	no	91
Warnings:					
Information:					
35	Non Patent Literature	ExB21-USPatentAppPub2001_0033600A1-Yang.pdf	4105685 e4ba5fc7dfa89435fec23d17786088e34081 68c6	no	140
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36	Non Patent Literature	ExB22-WO0038455.pdf	1545059 e5e61c802407664f58261dec7c93c9e9331a 4af0	no	43
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37	Non Patent Literature	ExB23-PCTWO9921391Publication-Andersson.pdf	2112017 b793d83d574b9c68d3f82d8bd7e2e823 2717b84e	no	72
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38	Non Patent Literature	ExB24-US7062294.pdf	2147843 b580cdf8d8b2538dbafa7d221b40f26b 46d6b9c0	no	76
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39	Non Patent Literature	ExB25-ResourceManagementInThirdGeneration.pdf	843251 3c26e5c8ce1b94e67cfbe9eb7acb370f 438dc664	no	29
Warnings:					
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40	Non Patent Literature	ExB26-AdaptiveTransmittingAntenna.pdf	740352 d9df8206b69bdc70877fd739da7a0c52 fe40d9e2	no	27
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41	Non Patent Literature	ExB27-ArraycommIntellicell.pdf	1287990 893069f606725dd836e27bf9c0f19255 5ac997de	no	41
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42	Non Patent Literature	ExC1-US5095531.pdf	2251607 ef5661396e32c6bb7174f0026cc2c302 cd427968	no	63
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43	Non Patent Literature	ExC2-US5602555.pdf	382351 3c8c7caa1d413c715444acd81c1567e5 00714de3	no	14
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Information:					

44	Non Patent Literature	ExC3-US5603089.pdf	278724 8b9d3d5f3124096f3d27e97f6db25c80b00fe18e	no	11
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45	Non Patent Literature	ExC4-US5649293.pdf	421438 b0f47bb734c8eb94bfcbbe22bbe3f2cbcbfac345	no	12
Warnings:					
Information:					
46	Non Patent Literature	ExC5-US5886988.pdf	1274170 7ee9badf7fcd32917bf262037c2650821c159aeb	no	28
Warnings:					
Information:					
47	Non Patent Literature	ExC6-US5890067.pdf	968099 b3c698292d966baa6a3c4bde3e6966d77c40ff81	no	17
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Information:					
48	Non Patent Literature	ExC7-US5966094.pdf	706511 6259969efe958fa6279914780e9670e7065aaf40	no	15
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49	Non Patent Literature	ExC8-US6233466.pdf	1117923 5ba5fdc7ccacff201dff3aaa05ad767e21508f26	no	31
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50	Non Patent Literature	ExC9-US6345188.pdf	1526373 1792890d0fefc378755f19c9bbad9b5b79ffca4e	no	59
Warnings:					
Information:					

51	Non Patent Literature	ExC10-US6667712.pdf	1124293 4d9c817d2f0b7698b660e30507c0b5932960a990	no	33
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Information:					
52	Non Patent Literature	ExC11-US6687492.pdf	760051 c99e7424e684b310543faccfa0672f6f59522e00	no	29
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53	Non Patent Literature	ExC12-US6694154.pdf	1176761 9b19bc06d8ca32564afb9b066360f23891b3d745	no	24
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54	Non Patent Literature	ExC13-US20020034967.pdf	1504260 4ff121eb47b0456f40fd472d65f5d06cb7b7eaff	no	44
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55	Non Patent Literature	ExC14-US6850741.pdf	1696158 08483979365b0490ac532a0ec91fe7f9d0394809	no	61
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Information:					
56	Non Patent Literature	ExC15-US7031336.pdf	638514 bc7311fd57df2e61c2665e497ea99fff9534b9d6	no	19
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57	Non Patent Literature	ExC16-US7054662.pdf	1559096 6032edf68f70eafcedbae899e0424c6291db58b5	no	68
Warnings:					
Information:					

58	Non Patent Literature	ExC17-US7289826.pdf	2082005 33a9a0d23ba8a9d0fbdd48849b85241785d55fb6	no	37
Warnings:					
Information:					
59	Non Patent Literature	ExC18-US7346365.pdf	2060340 a31f9a7c0f6df0e8186e01b468f4ba421bf27bad	no	36
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60	Non Patent Literature	ExC19-20030017853.pdf	951853 3c9ecf013483163b164e1c4895c2025308cedc13	no	25
Warnings:					
Information:					
		Total Files Size (in bytes):	103187756		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NUMBER	PATENT NUMBER	GROUP ART UNIT	REQUEST ID
15/486,245		2411	53048

PAIR Correspondence Address/Fee Address Change

The following fields have been changed to Customer Number 22145 on 12/12/2017 via Private PAIR in view of the certification copied below that authorized the change.

- Correspondence Address

The address for Customer Number 22145 is:
22145
KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

I certify, in accordance with 37 CFR 1.4(d)(4) that I am:

An attorney or Agent of Record registered to practice before the Patent and Trademark Office who has been given power of attorney in this application

Signature:	/Vladislav Z. Teplitskiy/
Name:	Vladislav Z. Teplitskiy
Registration Number:	68069

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

22145 7590 01/19/2018
KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

EXAMINER	
GANGULY, SUMITRA	

ART UNIT	PAPER NUMBER
2411	

NOTIFICATION DATE	DELIVERY MODE
01/19/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

KOS_Docketing@koslaw.com

Office Action Summary	Application No. 15/486,245	Applicant(s) DA SILVA ET AL.	
	Examiner Sumitra Ganguly	Art Unit 2411	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *9/15/2017*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1,4,5,7-10,16,19,20,22-25 and 31-46* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1,4,5,7-10,16,19,20,22-25 and 31-46* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date *7/7/17, 11/29/17*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

1. The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Response to Arguments

1. Applicant's arguments with respect to claims 1, 4, 5, 7-10, 16, 19, 20, 22-25 and 31-46 have been considered but are moot because of the new ground of rejection as provided below.

Information Disclosure Statement

2. The information disclosure statement filed on 11/29/2017 and 7/7/2017 have been received, and entered into the record. However, it is impractical for the examiner to review the references thoroughly with the number of references cited in this case. By signing off on the cited references on the accompanying 1449 forms, the examiner is merely acknowledging the submission and "consideration" of the cited references.

MPEP § 2004 bullet 13 recites: "It is desirable to avoid the submission of long lists of documents if it can be avoided. Eliminate clearly irrelevant and marginally pertinent cumulative information. If a long list is submitted, highlight those documents which have been specifically brought to applicant's attention and/or are known to be of most significance. See *Penn Yan Boats, Inc. v. Sea Lark Boats, Inc.*, 359 F. Supp. 948, 175 USPQ 260 (S.D. Fla. 1972), *aff 'd*, 479 F.2d 1338, 178 USPQ 577 (5th Cir. 1973),

cert. denied, 414 U.S. 874 (1974). But cf. *Molins PLC v. Textron Inc.*, 48 F.3d 1172, 33 USPQ2d 1823 (Fed. Cir. 1995)."

Further, it should be noted that an applicant's duty of disclosure of material and information is not satisfied by presenting a patent examiner with "a mountain of largely irrelevant [material] from which the examiner is presumed to have been able, with his experience and with adequate time, to have found the critical [material]. It ignores the real world conditions under which examiners work." *Rohm & Haas Co. v. Crystal Chemical co.*, 722 F.2d 1556, 1573 [220 USPQ 289] (Fed. Cir. 1983), *cert. Denied*, 469 U.S. 851 (1984). Patent applicant has a duty not just to disclose pertinent prior art references but to make a disclosure in such a way as not to "bury" it within other disclosures of less relevant prior art; see *Golden Valley Microwave Foods Inc. v. Weaver Popcorn Co. Inc.*, 24 USPQ2d 1801 (N.D. Ind. 1992); *Molins PLC v. Textron Inc.*, 26 USPQ2d 1889, at 1899 (D.Del 1992); *Penn Yan Boats, Inc. v. Sea Lark Boats, Inc. et al.*, 175 USPQ 260, at 272 (S.D. Fl. 1972).

Claim Rejections - 35 USC § 112

3. The following is a quotation of 35 U.S.C. 112(b):

> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.
>
> The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph: The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claims 1, 4, 5, 7-10, 16, 19, 20, 22-25, 31-46 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Regarding claim 1, line 27 recites in part "*…..the first and second feedback information…..*". Shouldn't this be "*…..the first and the second feedback information…..*"?

Line 37 recites in part "….*occur at least partly simultaneously*…..". It is unclear as to what is meant by "partly simultaneously" and what is it based on? The sentence seems to be incomplete.

Regarding claims 4-5, 7-10 and 31-32, these claims depend on claim 1 and thus are rejected on the same ground(s) stated for claim 1 above. Additionally, some dependent claims have their own indefiniteness issues and thus are additionally rejected as discussed below.

Regarding claim 4, lines 2-3 recite in part "…..*the processor-, the transceiver, or the smart antenna are further configured*…..". First, there seems to be a typo "-" at the end of "processor". Second, after "antenna" is it an "are" or should it be a "is" just like in line 19 of claim 1? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 5, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 19 of claim 1? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 8, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 19 of

claim 1? The use of "is" or "are" after “antenna” must be consistent throughout all claims.

Regarding claim 9, lines 2-3 recite in part “…..*the smart antenna are further configured*…..”. After “antenna” is it an “are” or should it be a “is” just like in line 19 of claim 1? The use of "is" or "are" after “antenna” must be consistent throughout all claims.

Regarding claim 10, lines 2-3 recite in part “…..*the smart antenna are further configured*…..”. After “antenna” is it an “are” or should it be a “is” just like in line 19 of claim 1? The use of "is" or "are" after “antenna” must be consistent throughout all claims.

Regarding claim 16, line 29 recites in part “*…..the first and second feedback information…..*”. Shouldn’t this be “*…..the first and the second feedback information…..*”?

Line 35 recites in part “….*occur at least partly simultaneously*…..”. It is unclear as to what is meant by “partly simultaneously” and what is it based on? The sentence seems to be incomplete.

Line 38 recites in part “….*client device a second transmission peak*…..”. Shouldn’t this be “….*client device, a second transmission peak*…..”?

Regarding claims 19-20 and 22-25, these claims depend on claim 16 and thus are rejected on the same ground(s) stated for claim 16 above. Additionally, some dependent claims have their own indefiniteness issues and thus are additionally rejected as discussed below.

Regarding claim 19, lines 2-3 recite in part "…..*the smart antenna <u>are</u> further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 22 of claim 16? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 20, lines 2-3 recite in part "…..*the smart antenna <u>are</u> further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 22 of claim 16? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 23, lines 2-3 recite in part "…..*the smart antenna <u>are</u> further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 22 of claim 16? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Lines 3-4 recite in part "…..*the first client via the modified*…..". Shouldn't this be "…..*the first client <u>device</u> via the modified*….."?

Regarding claim 24, lines 2-3 recite in part "…..*the smart antenna <u>are</u> further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 22 of claim 16? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 25, lines 2-3 recite in part "…..*the smart antenna <u>are</u> further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 22 of claim 16? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 33, line 24 recites in part "*…..the first and second feedback information…..*". Shouldn't this be "*…..the first and the second feedback information…..*"?

Line 30 recites in part "….*occur at least partly simultaneously*…..". It is unclear as to what is meant by "partly simultaneously" and what is it based on? The sentence seems to be incomplete

Regarding claims 34-43, these claims depend on claim 33 and thus are rejected on the same ground(s) stated for claim 33 above. Additionally, some dependent claims have their own indefiniteness issues and thus are additionally rejected as discussed below.

Regarding claim 34, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 21 of claim 33? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 35, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 21 of claim 33? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 36, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 21 of claim 33? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 37, line 1 recites in part "…..*as recited in claim 34,*…..". Shouldn't this be "…..*as recited in claim 35,*….."?

Lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 21 of claim 33? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 38, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 21 of claim 33? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 39, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 21 of claim 33? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 40, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 21 of claim 33? The use of "is" or "are" after "antenna" must be consistent throughout all claims.

Regarding claim 41, lines 2-3 recite in part "…..*where to place transmission peaks and transmission nulls*…..". Shouldn't this be "…..*where to place the transmission peaks and the transmission nulls*….."?

Line 4 recites in part "…..*is further based on part on information*…..". It is unclear as to what is meant here. Does it mean "…..*is further based on partly on information*….." or something else?

Regarding claim 43, line 2 recites in part "…..*as a function of θ or as the zeroes*…..". There is insufficient antecedent basis for "the" above.

Line 3 recites an equation. What are "w(z)", "w0", "w1z", "w2z^2" etc., what is "z" and where is θ in the equation?

Regarding claim 44, lines 18 and 22 recite in part "*…..index to a routing table…..*". Is this referring to a routing table different from the routing table of line 12 of this claim? If not, the "a" before routing table should be changed to "the".

Line 31 recites in part "….*occur at least partly simultaneously*…..". It is unclear as to what is meant by "partly simultaneously" and what is it based on? The sentence seems to be incomplete

Line 34 recites in part "….*client device a second transmission peak*…..". Shouldn't this be "….*client device, a second transmission peak*….."?

Regarding claims 45-46, these claims depend on claim 44 and thus are rejected on the same ground(s) stated for claim 44 above. Additionally, some dependent claims have their own indefiniteness issues and thus are additionally rejected as discussed below.

Regarding claim 45, lines 2-3 recite in part "…..*the smart antenna are further configured*…..". After "antenna" is it an "are" or should it be a "is" just like in line 13 of

claim 44? The use of "is" or "are" after “antenna” must be consistent throughout all claims.

Regarding claim 46, lines 2-3 recite in part “…..*the smart antenna <u>are</u> further configured*…..”. After “antenna” is it an “are” or should it be a “is” just like in line 13 of claim 44? The use of "is" or "are" after “antenna” must be consistent throughout all claims.

Conclusion

5. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Sumitra Ganguly whose telephone number is (571)272-0813. The examiner can normally be reached on Monday to Friday, 8 A.M to 5 P.M.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Andrew Lai can be reached on 571 272 9741. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/S.G/
Examiner, Art Unit 2411

/Andrew Lai/
Supervisory Patent Examiner, Art Unit 2411

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	Examiner Sumitra Ganguly	Art Unit 2411	Page 1 of 1

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Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 1 OF 8	Attorney Docket No.	1640-001.201

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Examiner Signature /SUMITRA GANGULY/	Date Considered 01/05/2018

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 7 OF 8	Attorney Docket No.	1640-001.201

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
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Examiner Signature	/SUMITRA GANGULY/	Date Considered	01/05/2018

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	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 8 OF 8	Attorney Docket No.	1640-001.201

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Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
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	153	Exhibits A1 – A30	
	154	Exhibits B1 – B27	
	155	Exhibits C1 – C27	

Examiner Signature	/SUMITRA GANGULY/	Date Considered	01/05/2018

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(Not for submission under 37 CFR 1.99)

Application Number	15486245
Filing Date	2017-04-12
First Named Inventor	Marcus DA SILVA
Art Unit	2411
Examiner Name	Sumitra GANGULY
Attorney Docket Number	E1027.800(T).US1D1C1C1

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	2	6714584	B1	2004-03-30	ISHII et al	

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	Application Number	15486245
	Filing Date	2017-04-12
	First Named Inventor	Marcus DA SILVA
	Art Unit	2411
	Examiner Name	Sumitra GANGULY
	Attorney Docket Number	E1027.800(T).US1D1C1C1

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	Application Number	15486245
	Filing Date	2017-04-12
	First Named Inventor	Marcus DA SILVA
	Art Unit	2411
	Examiner Name	Sumitra GANGULY
	Attorney Docket Number	E1027.800(T).US1D1C1C1

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Nicholas R. Transier/	Date (YYYY-MM-DD)	2017-07-07
Name/Print	Nicholas R. TRANSIER	Registration Number	68743

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1211	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1212	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1213	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1214	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1215	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1216	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1217	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1218	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1219	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1220	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1221	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
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S1225	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
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			USPAT; USOCR			19:07
S1227	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1228	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1229	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1230	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1231	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1232	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1233	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
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S1236	15	(VIVATO).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1237	1	S1234 and S1236	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
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S1239	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
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S1242	0	S1238 and S1239 and S1240 and S1241	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1243	9	S1238 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1244	5	S1239 and ((direct$5 focuss4$	US-PGPUB;	OR	ON	2018/01/05

		angular$4) near4 beam)	USPAT; USOCR			19:07
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S1246	1	S1241 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1247	0	S1238 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1248	0	S1238 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1249	9	S1238 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1250	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1251	24	peak same null same (coverage area) with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1252	201	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1253	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1254	397	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1255	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1256	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1257	2390	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1258	168	(detect$3 identify$3 observ$3 recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1259	115	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1260	162	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1261	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07

S1262	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1263	2	S1238 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1264	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1265	779	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1266	117	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1267	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1268	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1269	1	S1268 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1270	68743	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1271	8977	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1272	122	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S1271	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1273	1	S1268 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1274	1	S1268 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1275	8	S1272 and (side near2 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1276	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1277	14	S1276 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1278	89	S1276 and (side near3 lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1279	11	S1271 and S1276	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1280	26	S1270 and S1276	US-PGPUB;	OR	ON	2018/01/05

			USPAT			19:07
S1281	30321	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1282	41849	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal user)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1283	25087	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1284	77	S1282 same S1283	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1285	1485	S1282 and S1283	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1286	197	S1282 same3 S1283	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1287	39248	(coordinat$3 manag$3 perform$3 arrang$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1288	92	S1282 same S1287	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1289	215	S1282 same2 S1287	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1290	6	"13855410"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1291	6	S1290 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1292	1161	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1293	955059	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1294	19	S1292 same S1293	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1295	10259	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with (coordinat$4)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1296	53	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1297	1489	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1298	164	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam) and multi$1beam	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1299	42	S1298 and null	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1300	291	peak same null same (directi$5 near5	US-PGPUB;	OR	ON	2018/01/05

		beam)	USPAT; USOCR			19:07
S1301	20557	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1302	30	S1300 and S1301	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1303	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1304	6	"13855410"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1305	6	S1304 and first	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1306	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1307	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1308	7	"8412106" and (first adj directed)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1309	7	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1310	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1311	0	S1310 and (enrgy power) near3 (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1312	0	S1310 and (energy power) near3 (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1313	0	S1310 and (energy power) with (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1314	0	S1310 and (energy power) with (side	US-PGPUB;	OR	ON	2018/01/05

		near3 (lobe beam))	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			19:07
S1315	2	S1310 and (energy power) with (second near3 (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1316	14	S1310 and ((energy power) with (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1317	1	S1310 and ((energy power) with (directed near3 beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1318	2	S1310 and ((energy power) with (second near2 beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1319	6	"13855410"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1320	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1321	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1322	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1323	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1324	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1325	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1326	278	((Hujun) near2 (Yin)).INV.	US-PGPUB;	OR	ON	2018/01/05

			USPAT; USOCR			19:07
S1327	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1328	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1329	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1330	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1331	7	S1320 and S1321 and S1322 and S1323 and S1324 and S1325 and S1326 and S1327 and S1328 and S1329 and S1330	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1332	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1333	15	(VIVATO).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1334	1	S1331 and S1333	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1335	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1336	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1337	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1338	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1339	0	S1335 and S1336 and S1337 and S1338	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1340	9	S1335 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1341	5	S1336 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1342	5	S1337 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1343	1	S1338 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1344	0	S1335 and ((direct$5 focuss4$	US-PGPUB;	OR	ON	2018/01/05

		angular$4) near4 beam) and (antenna near4 assembly)	USPAT; USOCR			19:07
S1345	0	S1335 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1346	9	S1335 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1347	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1348	24	peak same null same (coverage area) with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1349	201	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1350	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1351	397	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1352	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1353	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1354	2390	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1355	168	(detect$3 identify$3 observ$3 recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1356	115	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1357	162	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1358	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1359	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1360	2	S1335 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1361	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07

S1362	779	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1363	117	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1364	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1365	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1366	1	S1365 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1367	68743	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1368	8977	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1369	122	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S1368	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1370	1	S1365 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1371	1	S1365 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1372	8	S1369 and (side near2 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1373	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1374	14	S1373 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1375	89	S1373 and (side near3 lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1376	11	S1368 and S1373	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1377	26	S1367 and S1373	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1378	30321	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1379	41849	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07

		direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal user)				
S1380	25087	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1381	77	S1379 same S1380	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1382	1485	S1379 and S1380	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1383	197	S1379 same3 S1380	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1384	39248	(coordinat$3 manag$3 perform$3 arrang$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1385	92	S1379 same S1384	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1386	215	S1379 same2 S1384	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1387	6	"13855410"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1388	6	S1387 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1389	1161	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1390	955059	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1391	19	S1389 same S1390	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1392	10259	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with (coordinat$4)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1393	53	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1394	1489	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1395	164	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam) and multi$1beam	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1396	42	S1395 and null	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1397	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1398	20557	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1399	30	S1397 and S1398	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1400	9	"8412106"	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:07

			USOCR			
S1401	6	"13855410"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1402	6	S1401 and first	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1403	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1404	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1405	7	"8412106" and (first adj directed)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1406	7	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1407	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1408	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1409	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1410	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1411	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1412	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1413	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1414	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1415	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1416	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1417	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1418	7	S1407 and S1408 and S1409 and S1410 and S1411 and S1412 and S1413 and S1414 and S1415 and S1416 and S1417	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1419	1964274	(VIVATO, INC).AS.	US-PGPUB;	OR	ON	2018/01/05

			USPAT; USOCR			19:07
S1420	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1421	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1422	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1423	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1424	0	S1422 and S1420 and S1421 and S1423	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1425	0	S1422 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1426	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1427	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1428	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1429	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1430	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1431	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1432	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1433	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1434	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1435	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1436	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1437	7	S1426 and S1427 and S1428 and S1429 and S1430 and S1431 and	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:07

		S1432 and S1433 and S1434 and S1435 and S1436	USOCR			
S1438	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1439	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1440	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1441	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1442	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1443	0	S1441 and S1439 and S1440 and S1442	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1444	0	S1441 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1445	0	S1441 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1446	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1447	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1448	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1449	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1450	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1451	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1452	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1453	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1454	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1455	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:07

			USOCR			
S1456	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1457	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1458	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1459	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1460	7	S1449 and S1450 and S1451 and S1452 and S1453 and S1454 and S1455 and S1456 and S1457 and S1458 and S1459	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1461	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1462	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1463	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1464	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1465	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1466	0	S1464 and S1462 and S1463 and S1465	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1467	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1468	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1469	2	S1468 and S1467	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1470	3165	H04W16/28.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1471	1391	H04W72/046.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1472	1706	H04B7/04.cpc.	US-PGPUB;	OR	ON	2018/01/05

			USPAT; USOCR			19:07
S1473	58	S1468 and S1470	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1474	15	S1468 and S1471	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1475	8	S1468 and S1472	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1476	3	("20020158801" | "20030073465" | "6611695").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1477	24	("5327143" | "5771017" | "5809141" | "6049307" | "6104935" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611695" | "6628235" | "6631277" | "6850741" | "6907269" | "7346365" | "20010033600" | "20020103013" | "20020158801" | "20030064752" | "20030073465" | "20030114196").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1478	4	"15260147"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1479	324	H04B7/00.cpc.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1480	1391	H04W72/046.cpc.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1481	23	S1480 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1482	23	S1480 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1483	28	("5327143" | "5771017" | "5809141" | "6049307" | "6104935" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611695" | "6628235" | "6631277" | "6850741" | "6907269" | "7346365" | "20010033600" | "20020103013" | "20020158801" | "20030064752" | "20030073465" | "20030114196" | "4231040" | "5987037" | "6091788" | "20040063468").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1484	22	S1483 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1485	1	S1483 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1486	20822	((detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with beam)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1487	31	((detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07

		with transmission)				
S1488	307	(detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1489	0	S1483 and (detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1490	0	(("XR") near3 ("COMMUNICATIONS") near3 ("LLC") near3 ("D/B/A") near3 ("VIVATO") near3 ("TECHNOLOGIES")).AANM.	USPAT	OR	ON	2018/01/05 19:07
S1491	31	(("DA") near3 ("SILVA") near3 ("Marcus")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1492	41	(("CRILLY") near3 ("William")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1493	345	(("BRENNAN") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1494	61	(("CONLEY") near3 ("Robert")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1495	96	(("ALAMOUTI") near3 ("Siavash")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1496	37	(("CASAS") near3 ("Eduardo")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1497	278	(("YIN") near3 ("Hujun")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1498	10	(("JOSE") near3 ("Bobby")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1499	127	(("CHOI") near3 ("Yang-Seok")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1500	173	(("TAROKH") near3 ("Vahid")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1501	13	(("MEHROTRA") near3 ("Praveen")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1502	8	S1491 and S1492 and S1493 and S1494 and S1495 and S1496 and S1497 and S1498 and S1499 and S1500 and S1501	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1503	11	"XR COMMUNICATIONS".AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1504	3	S1502 and S1503	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1505	3	(modify$3 alter$3 chang$3) near3	US-PGPUB;	OR	ON	2018/01/05

		(antenna near3 beam) with feedback	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			19:07
S1506	35	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1507	35	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1508	11	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (antenna near3 beam) with (feedback near3 information)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1509	182	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback near3 information)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1510	946	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1511	26	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback near3 information) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1512	1030	(transmit$4 send$3 transmission) near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1513	9	(transmit$4 send$3 transmission) near3 second near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2018/01/05 19:07

			IBM_TDB			
S1514	121	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1515	2834	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1516	83	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device) same (directional)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1517	5	"10700329"	US-PGPUB	OR	ON	2018/01/05 19:07
S1518	48	"6611695" "20030114196" "20030064752" "5327143"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1519	14	"7151951"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1520	1	"20020158801"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1521	1	"20030073465"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1522	231	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1523	706	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback quality interference) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1524	949	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near5 (beam) with (feedback quality interference) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1525	303	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07

S1526	16	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device) same (directional) and (different adj times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1527	1	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) with different near2 times	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1528	1	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) same different near2 times	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1529	15	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) same (different near2 times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1530	35	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile MS client user device) same (different near2 times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:07
S1531	3159	H04W16/28.cpc.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1532	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1533	7	S1531 and S1532	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1534	29	("4231040" | "5327143" | "5771017" | "5809141" | "5987037" | "6049307" | "6091788" | "6104935" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611695" | "6628235" | "6631277" | "6850741" | "6907269" | "7346365" | "9462589" | "20010033600" | "20020103013" | "20020158801" | "20030064752" | "20030073465" | "20030114196" | "20040063468").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07
S1535	29	("4231040" | "5327143" | "5771017" | "5809141" | "5987037" | "6049307" | "6091788" | "6104935" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611695" | "6628235" | "6631277"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:07

		| "6850741" | "6907269" | "7346365" | "9462589" | "20010033600" | "20020103013" | "20020158801" | "20030064752" | "20030073465" | "20030114196" | "20040063468").PN.				
S1536	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1537	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1538	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1539	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1540	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1541	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1542	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1543	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1544	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1545	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1546	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1547	7	S1536 and S1537 and S1538 and S1539 and S1540 and S1541 and S1542 and S1543 and S1544 and S1545 and S1546	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1548	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1549	15	(VIVATO).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1550	1	S1547 and S1549	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1551	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1552	5	("6141335" | "6337659" | "6631277"	US-PGPUB;	OR	ON	2018/01/05

		| "6850741" | "6907269").PN.	USPAT; USOCR			19:07
S1553	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1554	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1555	0	S1551 and S1552 and S1553 and S1554	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1556	9	S1551 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1557	5	S1552 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1558	5	S1553 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1559	1	S1554 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1560	0	S1551 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1561	0	S1551 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1562	9	S1551 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1563	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1564	24	peak same null same (coverage area) with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1565	201	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1566	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1567	397	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1568	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1569	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1570	2390	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:07
S1571	168	(detect$3 identify$3 observ$3	US-PGPUB;	OR	ON	2018/01/05

		recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	USPAT; USOCR			19:07
S1572	115	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1573	162	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1574	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1575	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1576	2	S1551 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1577	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1578	779	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1579	117	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1580	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1581	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1582	1	S1581 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1583	68743	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1584	8977	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1585	122	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S1584	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1586	1	S1581 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1587	1	S1581 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1588	8	S1585 and (side near2 lobe near2	US-PGPUB;	OR	ON	2018/01/05

		energy)	USPAT; USOCR			19:08
S1589	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1590	14	S1589 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1591	89	S1589 and (side near3 lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1592	11	S1584 and S1589	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1593	26	S1583 and S1589	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1594	30321	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1595	41849	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal user)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1596	25087	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1597	77	S1595 same S1596	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1598	1485	S1595 and S1596	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1599	197	S1595 same3 S1596	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1600	39248	(coordinat$3 manag$3 perform$3 arrang$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1601	92	S1595 same S1600	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1602	215	S1595 same2 S1600	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1603	6	"13855410"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1604	6	S1603 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1605	1161	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1606	955059	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1607	19	S1605 same S1606	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1608	10259	((direct$5 focuss4$ angular$4) near4	US-PGPUB;	OR	ON	2018/01/05

		(beam communicat$3)) with (coordinat$4)	USPAT; USOCR			19:08
S1609	53	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1610	1489	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1611	164	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam) and multi$1beam	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1612	42	S1611 and null	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1613	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1614	20557	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1615	30	S1613 and S1614	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1616	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1617	6	"13855410"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1618	6	S1617 and first	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1619	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1620	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1621	7	"8412106" and (first adj directed)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1622	7	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1623	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1624	0	S1623 and (enrgy power) near3 (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08

S1625	0	S1623 and (energy power) near3 (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1626	0	S1623 and (energy power) with (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1627	0	S1623 and (energy power) with (side near3 (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1628	2	S1623 and (energy power) with (second near3 (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1629	14	S1623 and ((energy power) with (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1630	1	S1623 and ((energy power) with (directed near3 beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1631	2	S1623 and ((energy power) with (second near2 beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1632	6	"13855410"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1633	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1634	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

			USOCR			
S1635	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1636	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1637	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1638	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1639	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1640	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1641	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1642	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1643	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1644	7	S1633 and S1634 and S1635 and S1636 and S1637 and S1638 and S1639 and S1640 and S1532 and S1642 and S1643	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1645	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1646	15	(VIVATO).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1647	1	S1644 and S1646	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1648	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1649	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1650	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1651	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1652	0	S1648 and S1649 and S1650 and S1651	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

			USOCR			
S1653	9	S1648 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1654	5	S1649 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1655	5	S1650 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1656	1	S1651 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1657	0	S1648 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1658	0	S1648 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1659	9	S1648 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1660	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1661	24	peak same null same (coverage area) with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1662	201	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1663	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1664	397	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1665	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1666	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1667	2390	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1668	168	(detect$3 identify$3 observ$3 recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1669	115	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1670	162	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08

S1671	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1672	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1673	2	S1648 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1674	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1675	779	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1676	117	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1677	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1678	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1679	1	S1678 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1680	68743	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1681	8977	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1682	122	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S1681	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1683	1	S1678 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1684	1	S1678 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1685	8	S1682 and (side near2 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1686	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1687	14	S1686 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1688	89	S1686 and (side near3 lobe)	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

			USOCR			
S1689	11	S1681 and S1686	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1690	26	S1680 and S1686	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1691	30321	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1692	41849	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal user)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1693	25087	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1694	77	S1692 same S1693	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1695	1485	S1692 and S1693	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1696	197	S1692 same3 S1693	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1697	39248	(coordinat$3 manag$3 perform$3 arrang$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1698	92	S1692 same S1697	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1699	215	S1692 same2 S1697	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1700	6	"13855410"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1701	6	S1700 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1702	1161	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1703	955059	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1704	19	S1702 same S1703	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1705	10259	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with (coordinat$4)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1706	53	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1707	1489	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1708	164	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08

		beam) and multi$1beam				
S1709	42	S1708 and null	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1710	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1711	20557	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1712	30	S1710 and S1711	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1713	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1714	6	"13855410"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1715	6	S1714 and first	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1716	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1717	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1718	7	"8412106" and (first adj directed)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1719	7	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1720	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1721	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1722	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1723	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1724	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1725	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1726	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1727	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08

S1728	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1729	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1730	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1731	7	S1720 and S1721 and S1722 and S1723 and S1724 and S1725 and S1726 and S1727 and S1728 and S1729 and S1730	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1732	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1733	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1734	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1735	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1736	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1737	0	S1735 and S1733 and S1734 and S1736	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1738	0	S1735 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1739	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1740	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1741	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1742	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1743	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1744	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1745	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08

S1746	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1747	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1748	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1749	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1750	7	S1739 and S1740 and S1741 and S1742 and S1743 and S1744 and S1745 and S1746 and S1747 and S1748 and S1749	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1751	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1752	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1753	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1754	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1755	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1756	0	S1754 and S1752 and S1753 and S1755	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1757	0	S1754 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1758	0	S1754 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1759	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1760	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1761	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1762	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1763	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08

S1764	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1765	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1766	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1767	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1768	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1769	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1770	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1771	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1772	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1773	7	S1762 and S1763 and S1764 and S1765 and S1766 and S1767 and S1768 and S1769 and S1770 and S1771 and S1772	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1774	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1775	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1776	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1777	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1778	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1779	0	S1777 and S1775 and S1776 and S1778	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1780	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" |	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08

		"6907269").PN.				
S1781	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1782	2	S1781 and S1780	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1783	3165	H04W16/28.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1784	1391	H04W72/046.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1785	1706	H04B7/04.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1786	58	S1781 and S1783	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1787	15	S1781 and S1784	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1788	8	S1781 and S1785	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1789	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1790	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1791	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1792	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1793	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1794	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1795	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1796	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1797	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1798	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1799	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

			USOCR			
S1800	7	S1789 and S1790 and S1791 and S1792 and S1793 and S1794 and S1795 and S1796 and S1797 and S1798 and S1799	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1801	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1802	15	(VIVATO).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1803	1	S1800 and S1802	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1804	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1805	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1806	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1807	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1808	0	S1804 and S1805 and S1806 and S1807	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1809	9	S1804 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1810	5	S1805 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1811	5	S1806 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1812	1	S1807 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1813	0	S1804 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1814	0	S1804 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1815	9	S1804 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1816	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1817	24	peak same null same (coverage area) with ((direct$5 angular focuss$5)	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

		near5 beam)	USOCR			
S1818	201	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1819	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1820	397	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1821	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1822	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1823	2390	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1824	168	(detect$3 identify$3 observ$3 recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1825	115	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1826	162	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1827	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1828	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1829	2	S1804 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1830	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1831	779	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1832	117	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1833	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1834	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1835	1	S1834 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08

S1836	68743	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1837	8977	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1838	122	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S1837	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1839	1	S1834 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1840	1	S1834 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1841	8	S1838 and (side near2 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1842	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1843	14	S1842 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1844	89	S1842 and (side near3 lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1845	11	S1837 and S1842	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1846	26	S1836 and S1842	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1847	30321	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1848	41849	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal user)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1849	25087	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1850	77	S1848 same S1849	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1851	1485	S1848 and S1849	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1852	197	S1848 same3 S1849	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1853	39248	(coordinat$3 manag$3 perform$3	US-PGPUB;	OR	ON	2018/01/05

		arrang$3) with (direct$3 near5 communication)	USPAT			19:08
S1854	92	S1848 same S1853	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1855	215	S1848 same2 S1853	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1856	6	"13855410"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1857	6	S1856 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1858	1161	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1859	955059	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1860	19	S1858 same S1859	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1861	10259	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with (coordinat$4)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1862	53	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1863	1489	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1864	164	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam) and multi$1beam	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1865	42	S1864 and null	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1866	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1867	20557	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1868	30	S1866 and S1867	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1869	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1870	6	"13855410"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1871	6	S1870 and first	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1872	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1873	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08

S1874	7	"8412106" and (first adj directed)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1875	7	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1876	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1877	0	S1876 and (enrgy power) near3 (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1878	0	S1876 and (energy power) near3 (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1879	0	S1876 and (energy power) with (side adj (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1880	0	S1876 and (energy power) with (side near3 (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1881	2	S1876 and (energy power) with (second near3 (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1882	14	S1876 and ((energy power) with (lobe beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1883	1	S1876 and ((energy power) with (directed near3 beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2018/01/05 19:08

			DERWENT; IBM_TDB			
S1884	2	S1876 and ((energy power) with (second near2 beam))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1885	6	"13855410"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S1886	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1887	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1888	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1889	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1890	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1891	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1892	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1893	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1894	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1895	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1896	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1897	7	S1886 and S1887 and S1888 and S1889 and S1890 and S1891 and S1892 and S1893 and S1894 and S1895 and S1896	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1898	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1899	15	(VIVATO).AS.	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

			USOCR			
S1900	1	S1897 and S1899	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1901	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1902	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1903	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1904	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1905	0	S1901 and S1902 and S1903 and S1904	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1906	9	S1901 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1907	5	S1902 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1908	5	S1903 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1909	1	S1904 and ((direct$5 focuss4$ angular$4) near4 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1910	0	S1901 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1911	0	S1901 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1912	9	S1901 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1913	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1914	24	peak same null same (coverage area) with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1915	201	peak same null with ((direct$5 angular focuss$5) near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1916	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1917	397	peak with null with (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08

S1918	1	"20030114196".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1919	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1920	2390	(sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1921	168	(detect$3 identify$3 observ$3 recogniz$3 find$3) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1922	115	((transmit$4 send$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1923	162	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1924	50	((transmit$4 send$3 transfer$4 spread$3 transport$3) near5 energy) with (sidelobe (side near2 lobe) (side$1lobe)) near3 (energy power) and @ad<="20021104"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1925	1	"3747109".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1926	2	S1901 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna) and computer	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1927	6	(null with maxim$4 near3 power with minim$3 near3 interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1928	779	(null with power with interference)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1929	117	(null with power with interference) with beam	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1930	1	"20030064752".PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1931	1	"8412106".PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1932	1	S1931 and (monitor$3)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1933	68743	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1934	8977	(maintain$3 stor$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08

S1935	122	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) same S1934	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1936	1	S1931 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1937	1	S1931 and (side near3 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1938	8	S1935 and (side near2 lobe near2 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1939	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1940	14	S1939 and (side near3 lobe near3 energy)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1941	89	S1939 and (side near3 lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1942	11	S1934 and S1939	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1943	26	S1933 and S1939	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1944	30321	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1945	41849	(maintain$3 stor$3 receiv$3) with ((transmit near3 power) (data with transmit near3 rate) (antenna near3 direction) (QoS (quality near3 service)) (timing near3 data)) with (client mobile UE WTRU terminal user)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1946	25087	(coordinat$3 mang$3 perform$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1947	77	S1945 same S1946	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1948	1485	S1945 and S1946	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1949	197	S1945 same3 S1946	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1950	39248	(coordinat$3 manag$3 perform$3 arrang$3) with (direct$3 near5 communication)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1951	92	S1945 same S1950	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1952	215	S1945 same2 S1950	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1953	6	"13855410"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1954	6	S1953 and (side adj lobe)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08

S1955	1161	signal with control with coordinat$3 with logic	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1956	955059	((direct$5 focuss4$ angular$4) near4 (beam communicat$3))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1957	19	S1955 same S1956	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1958	10259	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with (coordinat$4)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1959	53	((direct$5 focuss4$ angular$4) near4 (beam communicat$3)) with ((coordinat$4) near3 (logic circuit))	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1960	1489	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1961	164	(transmi$5 send$3) with (receiv$3 recep$4) with (directional near3 beam) and multi$1beam	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1962	42	S1961 and null	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S1963	291	peak same null same (directi$5 near5 beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1964	20557	H04W16/$.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1965	30	S1963 and S1964	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1966	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1967	6	"13855410"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1968	6	S1967 and first	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1969	9	"8412106"	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1970	0	"8412106" and (first adj directed adj beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1971	7	"8412106" and (first adj directed)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1972	7	"8412106" and (side adj lobe)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1973	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1974	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

			USOCR			
S1975	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1976	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1977	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1978	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1979	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1980	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1981	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1982	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1983	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1984	7	S1973 and S1974 and S1975 and S1976 and S1977 and S1978 and S1979 and S1980 and S1981 and S1982 and S1983	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1985	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1986	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1987	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1988	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1989	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1990	0	S1988 and S1986 and S1987 and S1989	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1991	0	S1988 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1992	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

			USOCR			
S1993	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1994	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1995	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1996	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1997	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1998	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S1999	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2000	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2001	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2002	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2003	7	S1992 and S1993 and S1994 and S1995 and S1996 and S1997 and S1998 and S1999 and S2000 and S2001 and S2002	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2004	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2005	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2006	7	("20040063468" | "4231040" | "5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2007	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2008	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2009	0	S2007 and S2005 and S2006 and S2008	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2010	0	S2007 and ((direct$5 focuss4$ angular$4) near4 beam) and	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

		(antenna near4 assembly)	USOCR			
S2011	0	S2007 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2012	914	peak same null same (coverage area)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2013	1055	peak same null same (beam)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2014	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2015	28	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2016	41	((William) near2 (Crilly)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2017	341	((James) near2 (Brennan)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2018	61	((Robert) near2 (Conley)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2019	96	((Siavash) near2 (Alamouti)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2020	37	((Eduardo) near2 (Casas)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2021	278	((Hujun) near2 (Yin)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2022	10	((Bobby) near2 (Jose)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2023	127	((Yang-Seok) near2 (Choi)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2024	173	((Vahid) near2 (Tarokh)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2025	13	((Praveen) near2 (Mehrotra)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2026	7	S2015 and S2016 and S2017 and S2018 and S2019 and S2020 and S2021 and S2022 and S2023 and S2024 and S2025	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2027	1964274	(VIVATO, INC).AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2028	5	("6141335" | "6337659" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2029	7	("20040063468" | "4231040" |	US-PGPUB;	OR	ON	2018/01/05

		"5809141" | "6104935" | "6169910" | "6311075" | "6611695").PN.	USPAT; USOCR			19:08
S2030	13	("20010033600" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6169910" | "6311075" | "6438376" | "6470195" | "6611695" | "6628235").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2031	1	("5327143").PN.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2032	0	S2030 and S2028 and S2029 and S2031	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2033	20	("20010033600" | "20020158801" | "20030073465" | "20040063468" | "5771017" | "5809141" | "5987037" | "6091788" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611895" | "6628235" | "6631277" | "6850741" | "6907269").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2034	4877	(sidelobe (side near2 lobe) (side$1lobe)) with (energy power)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2035	2	S2034 and S2033	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2036	3165	H04W16/28.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2037	1391	H04W72/046.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2038	1706	H04B7/04.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2039	58	S2034 and S2036	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2040	15	S2034 and S2037	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2041	8	S2034 and S2038	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2042	3	("20020158801" | "20030073465" | "6611695").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2043	24	("5327143" | "5771017" | "5809141" | "6049307" | "6104935" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611695" | "6628235" | "6631277" | "6850741" | "6907269" | "7346365" | "20010033600" | "20020103013" | "20020158801" | "20030064752" | "20030073465" | "20030114196").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2044	4	"15260147"	US-PGPUB;	OR	ON	2018/01/05

			USPAT			19:08
S2045	324	H04B7/00.cpc.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2046	1391	H04W72/046.cpc.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2047	23	S2046 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2048	23	S2046 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2049	28	("5327143" | "5771017" | "5809141" | "6049307" | "6104935" | "6108323" | "6141335" | "6169910" | "6311075" | "6337659" | "6438376" | "6470195" | "6611695" | "6628235" | "6631277" | "6850741" | "6907269" | "7346365" | "20010033600" | "20020103013" | "20020158801" | "20030064752" | "20030073465" | "20030114196" | "4231040" | "5987037" | "6091788" | "20040063468").PN.	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2050	22	S2049 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna)	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2051	1	S2049 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2052	20822	((detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with beam)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2053	31	((detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe)) with transmission)	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2054	307	(detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2055	0	S2049 and (detect$3 recogniz$3 find$2 identify$3 notic$3 observ$3) with energy with (side near3 (beam lobe))	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2056	0	(("XR") near3 ("COMMUNICATIONS") near3 ("LLC") near3 ("D/B/A") near3 ("VIVATO") near3 ("TECHNOLOGIES")).AANM.	USPAT	OR	ON	2018/01/05 19:08
S2057	31	(("DA") near3 ("SILVA") near3 ("Marcus")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2058	41	(("CRILLY") near3 ("William")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2059	345	(("BRENNAN") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2060	61	(("CONLEY") near3 ("Robert")).INV.	US-PGPUB; USPAT;	OR	ON	2018/01/05 19:08

			USOCR			
S2061	96	(("ALAMOUTI") near3 ("Siavash")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2062	37	(("CASAS") near3 ("Eduardo")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2063	278	(("YIN") near3 ("Hujun")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2064	10	(("JOSE") near3 ("Bobby")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2065	127	(("CHOI") near3 ("Yang-Seok")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2066	173	(("TAROKH") near3 ("Vahid")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2067	13	(("MEHROTRA") near3 ("Praveen")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2068	8	S2057 and S2058 and S2059 and S2060 and S2061 and S2062 and S2063 and S2064 and S2065 and S2066 and S2067	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2069	11	"XR COMMUNICATIONS".AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2070	3	S2068 and S2069	US-PGPUB; USPAT; USOCR	OR	ON	2018/01/05 19:08
S2071	3	(modify$3 alter$3 chang$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2072	35	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2073	35	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2074	11	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (antenna near3 beam) with (feedback near3 information)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2018/01/05 19:08

			IBM_TDB			
S2075	182	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback near3 information)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2076	946	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2077	26	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback near3 information) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2078	1030	(transmit$4 send$3 transmission) near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2079	9	(transmit$4 send$3 transmission) near3 second near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2080	121	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2081	2834	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2082	83	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device) same (directional)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2083	5	"10700329"	US-PGPUB	OR	ON	2018/01/05 19:08
S2084	48	"6611695" "20030114196"	US-PGPUB;	OR	ON	2018/01/05

		"20030064752" "5327143"	USPAT			19:08
S2085	14	"7151951"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2086	1	"20020158801"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2087	1	"20030073465"	US-PGPUB; USPAT	OR	ON	2018/01/05 19:08
S2088	231	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2089	706	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback quality interference) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2090	949	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near5 (beam) with (feedback quality interference) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2091	303	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2092	16	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information signal quality interference feedback) near3 (UE WTRU mobile client user device) same (directional) and (different adj times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2093	1	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) with different near2 times	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2094	1	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device) same different near2 times	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2095	15	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS;	OR	ON	2018/01/05 19:08

		same (different near2 times)	EPO; JPO; DERWENT; IBM_TDB			
S2096	35	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile MS client user device) same (different near2 times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:08
S2097	18	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near5 (beam near3 pattern) with (feedback) near3 (UE WTRU mobile client user MT)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/01/05 19:09

1/5/2018 8:08:16 PM
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15486245	DA SILVA ET AL.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

CPC- SEARCHED		
Symbol	Date	Examiner
H04B7/00, H04W16/28	6/5/17	S.G
H04B7/00, H04W16/28	1/5/18	S.G

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor, Assignee and Teaxt search in EAST. See search history printout for details.	6/5/17	S.G.
Updated search. See search history printout for details.	1/5/18	S.G.

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15486245	DA SILVA ET AL.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/05/2017	01/05/2018							
	1	✓	✓							
	2	✓	-							
	3	✓	-							
	4	✓	✓							
	5	✓	✓							
	6	✓	-							
	7	✓	✓							
	8	✓	✓							
	9	✓	✓							
	10	✓	✓							
	11	✓	-							
	12	✓	-							
	13	✓	-							
	14	✓	-							
	15	✓	-							
	16	✓	✓							
	17	✓	-							
	18	✓	-							
	19	✓	✓							
	20	✓	✓							
	21	✓	-							
	22	✓	✓							
	23	✓	✓							
	24	✓	✓							
	25	✓	✓							
	26	✓	-							
	27	✓	-							
	28	✓	-							
	29	✓	-							
	30	✓	-							
	31		✓							
	32		✓							
	33		✓							
	34		✓							
	35		✓							
	36		✓							

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15486245	DA SILVA ET AL.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/05/2017	01/05/2018							
	37		✓							
	38		✓							
	39		✓							
	40		✓							
	41		✓							
	42		✓							
	43		✓							
	44		✓							
	45		✓							
	46		✓							

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 22145

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

XR Communications, LLC d/b/a Vivato Technologies

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	1/10/2018
Name	Kai Hansen		
Title	Managing Member		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Electronic Acknowledgement Receipt

EFS ID:	31908542
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	22145
Filer:	Glen L. Nuttall/Mariel Boyan
Filer Authorized By:	Glen L. Nuttall
Attorney Docket Number:	1640-001.201
Receipt Date:	27-FEB-2018
Filing Date:	12-APR-2017
Time Stamp:	20:05:31
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		1640-001-201--POAAsFiled02272018.pdf	208705 1e85d019e74017e1b4f29f3a04281864008 7fb68	yes	2

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	1
	Power of Attorney	2	2

Warnings:

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Information:

Total Files Size (in bytes):	208705

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	15/486,245
Filing Date	April 12, 2017
First Named Inventor	Marcus Da Silva
Title	DIRECTED WIRELESS COMMUNICATION
Art Unit	2411
Examiner Name	Ganguly, Sumitra
Attorney Docket Number	1640-001.201

SIGNATURE of Applicant or Patent Practitioner

Signature		Date (Optional)	February 27, 2018
Name	Glen L. Nuttall	Registration Number	46,188
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ *Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201

CONFIRMATION NO. 4888

22145
KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

POA ACCEPTANCE LETTER

OC000000097738848

Date Mailed: 03/01/2018

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/27/2018.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/sibrahim/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201

CONFIRMATION NO. 4888

22145
KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

POWER OF ATTORNEY NOTICE

OC000000097738839

Date Mailed: 03/01/2018

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/27/2018.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/sibrahim/

PTO/SB/30 (11-17)
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Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	15/486,245
Filing Date	April 12, 2017
First Named Inventor	Marcus Da Silva
Art Unit	2411
Examiner Name	Sumitra Ganguly
Attorney Docket Number	1640-001.201

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

      ii. ☐ Other _____

   b. ☑ Enclosed

      i. ☑ Amendment/Reply

      ii. ☐ Affidavit(s)/ Declaration(s)

      iii. ☐ Information Disclosure Statement (IDS)

      iv. ☐ Other _____

2. Miscellaneous

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☑ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 11-1159.

      i. ☑ RCE fee required under 37 CFR 1.17(e)

      ii. ☑ Extension of time fee (37 CFR 1.136 and 1.17)

      iii. ☐ Other _____

   b. ☐ Check in the amount of $ _____ enclosed

   c. ☑ Payment by credit card (Form PTO-2038 enclosed)

   d. ■ Payment by EFS-Web

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/Glen L. Nuttall/	Date	June 19, 2018
Name (Print/Type)	Glen L. Nuttall	Registration No.	46,188

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being EFS-Web transmitted to the United States Patent and Trademark Office (USPTO), deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop RCE, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450 or facsimile transmitted to the USPTO on the date shown below.

Signature			
Name (Print/Type)		Date	

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Marcus Da Silva
Serial No.	:	15/486,245
Filed	:	April 12, 2017
For	:	DIRECTED WIRELESS COMMUNICATION
Examiner	:	Sumitra Ganguly
Art Unit	:	2411
Confirmation No.	:	4888

OFFICE ACTION RESPONSE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

In response to the Office action transmitted January 19, 2018, and in connection with the Request for Continued Examination filed herewith, please reconsider the above-captioned application in light of the following amendments and remarks.

Amendments to the Claims are set forth in the listing of the claims beginning on page 2 of this paper; and

Remarks/Arguments begin on page 12 of this paper.

AMENDMENTS TO THE CLAIMS

Please amend the claims to read as follows. Additions are underlined. Deletions are in ~~strikeout~~ text or [[double brackets]].

1. (Currently Amended) A data-communications networking apparatus, comprising:

a processor configured to:

generate a probing signal for transmission to at least a first client device and a second client device;

generate a first data stream for transmission to the first client device; and

generate a second data stream for transmission to the second client device; and

a transceiver operatively coupled to the processor and configured to:

transmit the probing signal to at least the first client device and the second client device via a smart antenna;

wherein the smart antenna is operatively coupled to the transceiver and comprises a first antenna element and a second antenna element;

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information from the first client device in response to the transmission of the probing signal;

receive a second feedback information from the second client device in response to the transmission of the probing signal;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals; and

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein ~~the transmissions~~ transmission of the first data stream and

transmission of at least part of the second data stream occur at ~~least partly simultaneously~~the same time; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

2. – 3. (Cancelled)

4. (Currently Amended) The data-communications networking apparatus as recited in Claim 1, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: determine a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals.

5. (Currently Amended) The data-communications networking apparatus as recited in Claim 1, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals.

6. (Cancelled)

7. (Previously Presented) The data-communications networking apparatus as recited in Claim 1, wherein the first feedback information and the second feedback information comprise at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, timing data, or an index to a routing table.

8. (Currently Amended) The data-communications networking apparatus as recited in Claim 5, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: transmit a third data stream to the first client device via the modified one or more spatially distributed patterns of electromagnetic signals.

9. (Currently Amended) The data-communications networking apparatus as recited in Claim 5, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: determine a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals, wherein the first set of weights

and the second set of weights are different.

10. (Currently Amended) The data-communications networking apparatus as recited in Claim 5, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to:

modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals; and

transmit a third data stream to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals.

11. – 15. (Cancelled)

16. (Currently Amended) A data-communications networking apparatus, comprising:

a processor configured to:

generate a probing signal for transmission to at least a first client device and a second client device;

generate a first data stream for transmission to the first client device; and

generate a second data stream for transmission to the second client device; and

a transceiver operatively coupled to the processor, and configured to:

transmit the probing signal to at least the first client device and the second client device via a smart antenna;

wherein the smart antenna is operatively coupled to the transceiver and comprises a first antenna element and a second antenna element;

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information from the first client device;

receive a second feedback information from the second client device;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals; and

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein ~~the transmissions~~ transmission of the first data stream and transmission of at least part of the second data stream occur at the same time~~least partly simultaneously~~; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device, a second transmission peak at a location of the second client device, and a first transmission null at a location of a third device.

17. – 18. (Cancelled)

19. (Currently Amended) The data-communications networking apparatus as recited in Claim 16, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: determine a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals.

20. (Currently Amended) The data-communications networking apparatus as recited in Claim 16, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals.

21. (Cancelled)

22. (Previously Presented) The data-communications networking apparatus as recited in Claim 16, wherein the first feedback information and the second feedback information comprises at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, timing data, or an index to a routing table.

23. (Currently Amended) The data-communications networking apparatus as recited in Claim 20, wherein one or more of the processor, the transceiver, or the smart

antenna ~~are~~ is further configured to: transmit a third data stream to the first client device via the modified one or more spatially distributed patterns of electromagnetic signals.

24. (Currently Amended) The data-communications networking apparatus as recited in Claim 20, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: determine a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals, wherein the first set of weights and the second set of weights are different.

25. (Currently Amended) The data-communication networking apparatus as recited in Claim 20, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to:

modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals; and

transmit a third data stream to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals.

26. – 30. (Cancelled)

31. (Previously Presented) The data-communications networking apparatus as recited in Claim 1, wherein the one or more spatially distributed patterns of electromagnetic signals are further configured to exhibit a first transmission null at a location of a third device.

32. (Previously Presented) The data-communications networking apparatus as recited in Claim 31, wherein the one or more spatially distributed patterns of electromagnetic signals are further configured to exhibit a second transmission null at a location of a fourth device.

33. (Currently Amended) A data-communications networking apparatus, comprising:

a processor configured to:

generate a probing signal for transmission to at least a first client device and a second client device;

generate a first data stream for transmission to the first client device; and

generate a second data stream for transmission to the second client device; and

a transceiver operatively coupled to the processor and configured to:

transmit the probing signal to at least the first client device and the second client device via a smart antenna;

wherein the smart antenna is operatively coupled to the transceiver;

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information from the first client device;

wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table;

receive a second feedback information from the second client device;

wherein the second feedback information comprises one or more of: a second amplitude information, a second phase information, a second routing information, or a second index to a routing table;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein ~~the transmissions~~ transmission of the first data stream and transmission of at least part of the second data stream occur ~~at least partly~~ simultaneously; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

34. (Currently Amended) The data-communications networking apparatus as recited in Claim 33, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: determine a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals.

35. (Currently Amended) The data-communications networking apparatus as recited in Claim 33, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals.

36. (Currently Amended) The data-communications networking apparatus as recited in Claim 35, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: transmit a third data stream to the first client device via the modified one or more spatially distributed patterns of electromagnetic signals.

37. (Currently Amended) The data-communications networking apparatus as recited in Claim 34, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: determine a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals, wherein the first set of weights and the second set of weights are different.

38. (Currently Amended) The data-communications networking apparatus as recited in Claim 35, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to:

modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals; and

transmit a third data stream to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals.

39. (Currently Amended) The data-communications networking apparatus as recited in Claim 36, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: determine a second set of weights to apply to the one or

more spatially distributed patterns of electromagnetic signals, wherein the first set of weights and the second set of weights are different.

40. (Currently Amended) The data-communications networking apparatus as recited in Claim 39, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to:

modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of the second set of weights to the one or more spatially distributed patterns of electromagnetic signals; and

transmit a fourth data stream to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals.

41. (Currently Amended) The data-communications networking apparatus as recited in Claim 33, further comprising a memory, wherein the determination of where to place the transmission peaks and the transmission nulls within one or more spatially distributed patterns of electromagnetic signals is further based ~~on part~~ partly on information contained within the routing table, wherein the routing table is stored in the memory.

42. (Previously Presented) The data-communications networking apparatus as recited in Claim 41, wherein the routing table comprises weighting values.

43. (Cancelled)

44. (Currently Amended) A data-communications networking apparatus, comprising:

a processor configured to:

generate a probing signal for transmission to at least a first client device and a second client device;

generate a first data stream for transmission to the first client device; and

generate a second data stream for transmission to the second client device;

a transceiver operatively coupled to the processor and configured to:

transmit the probing signal to at least the first client device and the second client device via a smart antenna;

wherein the smart antenna is operatively coupled to the transceiver; and

a memory operatively coupled to one or more of the processor or the transceiver;

wherein a routing table is stored in the memory;

wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:

receive a first feedback information from the first client device;

wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first ~~index to a~~ routing table index;

receive a second feedback information from the second client device;

wherein the second feedback information comprises one or more of: a second amplitude information, a second phase information, a second routing information, or a second ~~index to a~~ routing table table;

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first feedback information and the second feedback information;

transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals;

transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals;

wherein ~~the transmissions~~ transmission of the first data stream and transmission of at least part of the second data stream occur ~~at least partly~~ simultaneously; and

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device, a second transmission peak at a location of the second client device, and a first transmission null at a location of a third device.

45. (Currently Amended) The data-communications networking apparatus as recited in Claim 44, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: determine a first set of weights to apply to the one or

more spatially distributed patterns of electromagnetic signals.

46. (Currently Amended) The data-communications networking apparatus as recited in Claim 44, wherein one or more of the processor, the transceiver, or the smart antenna ~~are~~ is further configured to: modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals.

47. (New) The data-communications networking apparatus as recited in Claim 1, wherein the processor, transceiver and smart antenna are part of an access point configured to support the first and second client devices in accordance with an 802.11 standard, and wherein a position of the access point is fixed.

48. (New) The data-communications networking apparatus as recited in Claim 47, wherein the location of the first client device is not within a line of sight of the smart antenna.

49. (New) The data-communications networking apparatus as recited in Claim 16, configured for a wireless local area network.

50. (New) The data-communications networking apparatus as recited in Claim 49, wherein a position of the smart antenna is fixed.

51. (New) The data-communications networking apparatus as recited in Claim 50, configured to support the first and second client devices in accordance with an IEEE 802.11 standard.

REMARKS

By this paper Claims 1, 4, 5, 8-10, 16, 19, 20, 23-25, 33-41, and 44-46 have been amended, and Claim 43 has been cancelled without prejudice. Applicant reserves the right to purse the subject matter of the cancelled claim in the future. New Claims 47-51 have been added. As such, Claims 1, 4, 5, 7-10, 16, 19, 20, 22-25, 31-42, and 44-51 are currently pending for consideration in this application.

Rejections Under 35 USC 112

The Office Action rejected several of the claims under 35 USC 112 as being indefinite. Several of the claims have been amended to address and resolve the grounds for these rejections. For example, there were several instances in which the use of "is" and "are" was inconsistent. The amendments resolve this inconsistency. Some of the amendments also resolved other informalities such as consistent use of "the" and appropriate insertion of commas. As for Claims 1, 16, 33 and 44, the Office Action stated that the term "partly simultaneously" was unclear. Each of these claims was amended to increase clarity.

Applicant submits that the claims as amended address and resolve each ground identified by the Office Action, and respectfully requests withdrawal of the rejections.

New Claims

New Claims 47-51 have been added to more thoroughly recite subject matter considered to be part of the invention. Each of the new claims is supported by the application as filed. No new matter is added.

Conclusion

For the foregoing reasons, it is respectfully submitted that the rejections set forth in the outstanding Office action are inapplicable to the current claims. Accordingly, issuance of a Notice of Allowance is requested.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1159.

Respectfully submitted,
Klein, O'Neill & Singh, LLP

Dated: June 19, 2018
By /Glen L Nuttall/
Glen L Nuttall, Reg. No. 46,188

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Electronic Patent Application Fee Transmittal

Application Number:	15486245
Filing Date:	12-Apr-2017
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Filer:	Glen L. Nuttall
Attorney Docket Number:	1640-001.201

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	2202	4	50	200
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Extension - 2 months with $0 paid	2252	1	300	300
Miscellaneous:				
RCE- 1ST REQUEST	2801	1	650	650
		Total in USD ($)		**1150**

Electronic Acknowledgement Receipt	
EFS ID:	32944714
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	22145
Filer:	Glen L. Nuttall
Filer Authorized By:	
Attorney Docket Number:	1640-001.201
Receipt Date:	20-JUN-2018
Filing Date:	12-APR-2017
Time Stamp:	01:50:01
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1150
RAM confirmation Number	062018INTEFSW01530800
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		doc08330020180619224809.pdf	812677 4549b28316082dd0afc73de5416adef504840761	yes	14

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Request for Continued Examination (RCE)	2	2
Response After Final Action	3	3
Claims	4	13
Applicant Arguments/Remarks Made in an Amendment	14	14

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2	Fee Worksheet (SB06)	fee-info.pdf	33661 6b7bc8dc6b81c6bcd43b49e35d9e767c004df4a5	no	2

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Marcus Da Silva et al.	
Title:	DIRECTED WIRELESS COMMUNICATION	
Serial No.:	15/486,245	Filed: April 12, 2017
Examiner:	Sumitra Ganguly	Group Art Unit: 2411
Attorney Docket No.:	1640-001.201	

CERTIFICATE OF EFS-WEB TRANSMISSION
UNDER 37 CFR § 1.8

I hereby certify that the enclosed Request for Continued Examination (1 page); Office Action Response (12 pages); and Payment by Credit Card are being transmitted to the United States Patent and Trademark Office from the Pacific Time Zone via EFS-Web on June 19, 2018.

Date: June 19, 2018

/Glen L. Nuttall/

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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/486,245	Filing Date 04/12/2017	☐ To be Mailed

ENTITY: ☐ LARGE ☒ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	06/20/2018	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 34	Minus	** 30	= 4	X $50 =	200
	Independent (37 CFR 1.16(h))	* 4	Minus	***4	= 0	X $230 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	**200**

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
JAMES MASON

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 1 OF 3	Attorney Docket No.	1640-001.201

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	5,345,599 A	09-06-1994	Paulraj et al.	
	2	5,515,378 A	05-07-1996	Roy, III et al.	
	3	5,548,813 A	08-20-1996	Charas et al.	
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	22	2004/0066762 A1	04-08-2004	Alastalo	

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Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	23	GB 2349045 A	10-18-2000	Khalab		
	24	WO 00/038455 A1	06-29-2000	Jetzek		
	25	WO 02/063836 A2	08-15-2002	Alastalo		

Examiner Signature	Date Considered

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 2 OF 3	Attorney Docket No.	1640-001.201

FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	26	EP 1117270 A2	07-18-2001	Aravamudan et al.		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	27	Petition for Inter Partes Review of U.S. Patent No. 6,611,231; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00762; pages 1-92.	
	28	Petition for Inter Partes Review of U.S. Patent No. 7,729,728; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00763; pages 1-72.	
	29	Petition for Inter Partes Review of U.S. Patent No. 7,062,296; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00764; pages 1-83.	
	30	Petition for Inter Partes Review of U.S. Patent No. 7,062,296; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00725; pages 1-68.	
	31	Petition for Inter Partes Review of U.S. Patent No. 7,729,728; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; pages 1-53.	
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Examiner Signature	Date Considered
***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

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PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 3 OF 3	Attorney Docket No.	1640-001.201

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
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	48	IEEE Standards Bearer (Oct. 1997)	
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	50	Petition for Inter Partes Review of U.S. Patent No. 7,062,296; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01017; 79 pages.	
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Examiner Signature	Date Considered
*Examiner: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

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(12) UK Patent Application (19) GB (11) 2 349 045 (13) A

(43) Date of A Publication 18.10.2000

(21) Application No 9908839.5

(22) Date of Filing 16.04.1999

(51) INT CL[7]
H04Q 7/36 , H01Q 1/24 3/26 , H04Q 7/30

(52) UK CL (Edition R)
H4L LDSG LDSL L1H10
H1Q QFC

(56) Documents Cited
GB 2328800 A GB 2318947 A GB 2316807 A
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(54) Abstract Title
Base station transmission beam pattern forming; interference reduction

(57) A base station identifies, for a particular or desired mobile user, one or more other mobile users that are to be treated as vulnerable users potentially adversely affected by a downlink signal transmission from the base station to the desired user. A downlink transmission beam pattern is then formed which has a main beam with a direction matching the direction of the desired user and one or more nulls matching the direction or directions of one or more vulnerable users. Transmission data rate to the desired user and/or distance to the desired user may be used as criteria in determining whether this transmission is likely to render other users vulnerable to interference. A user data register (UDR) 14 stores data including direction of arrival (DOA) data for signals received by the base station from the desired and vulnerable users. From data in the UDR 14, a selection unit 16 determines one or more of: the DOA information for the desired user, distances of users from the base station, users who are close to high bit rate users, and users close to clusters of other users. From that data, a list of vulnerable users is generated by the unit 16 which sends the direction information for the desired and vulnerable users to an optimum weights unit 12 which calculates weights input to a downlink beamformer 20 so that the required beam pattern may be formed by transmission antenna elements. Any users for whom provision of a null would degrade the pattern for the desired user are removed from the vulnerable list. Where there is a cluster of vulnerable users, a null may be formed in the mean direction of the cluster. With N transmission antenna elements, N- 1 nulls can be formed, so that if there are more than N-1 vulnerable users, the N- 1 most vulnerable users are selected.

The receiving section of the base station may have an adaptive beamformer with an adaptive algorithm 26 which inputs a weight vector to a vector multiplier 22. A direction of arrival (DOA) determining unit 30 estimates the DOA of a user from the weight vector. The unit 30 may estimate the DOA by finding the peak of the uplink beam pattern, eg. by calculating the uplink beamformer gain at different DOAs and identifying the DOA for which the gain is the highest.

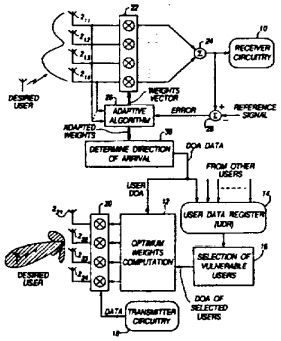

Fig.2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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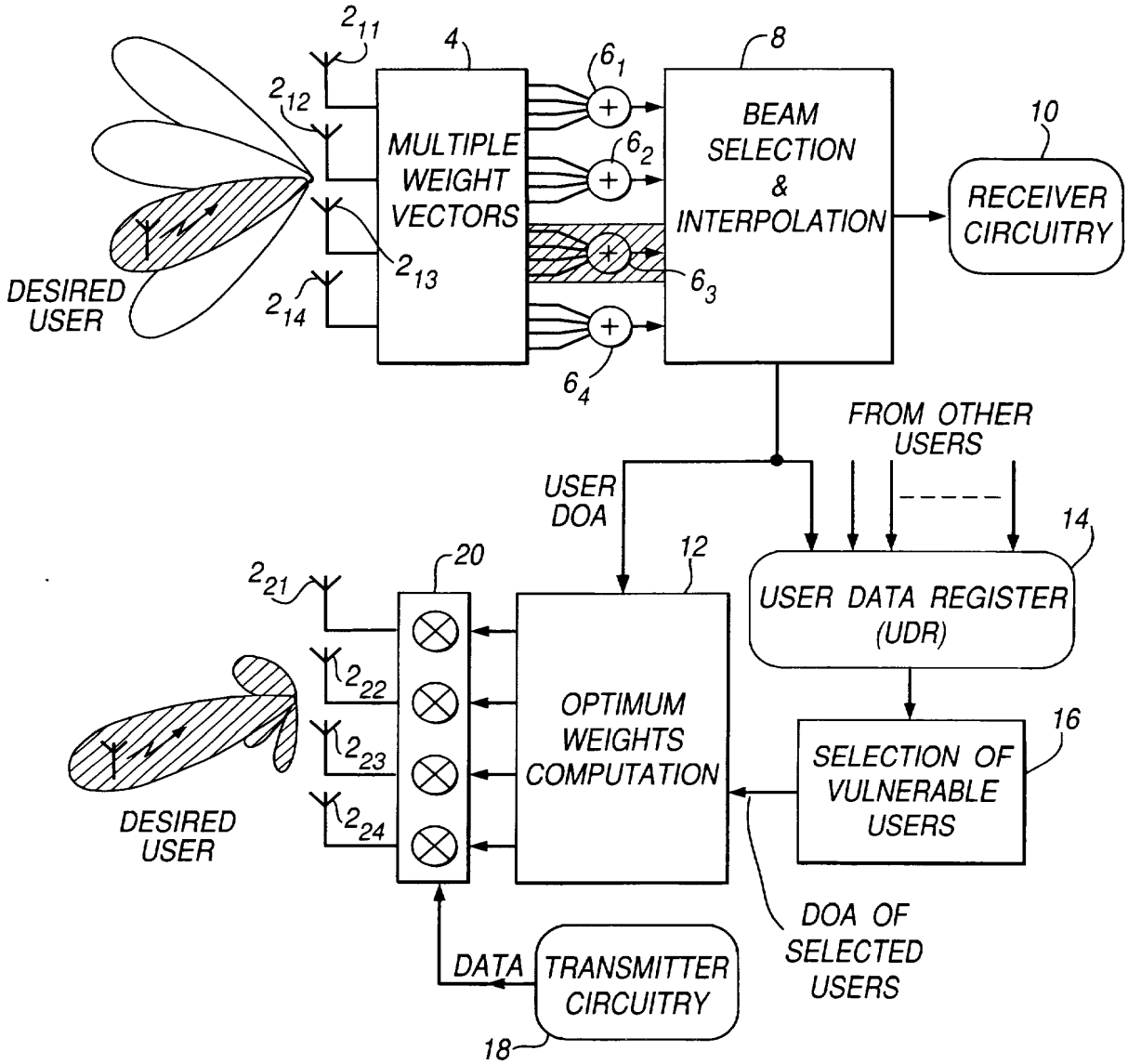

Fig.1

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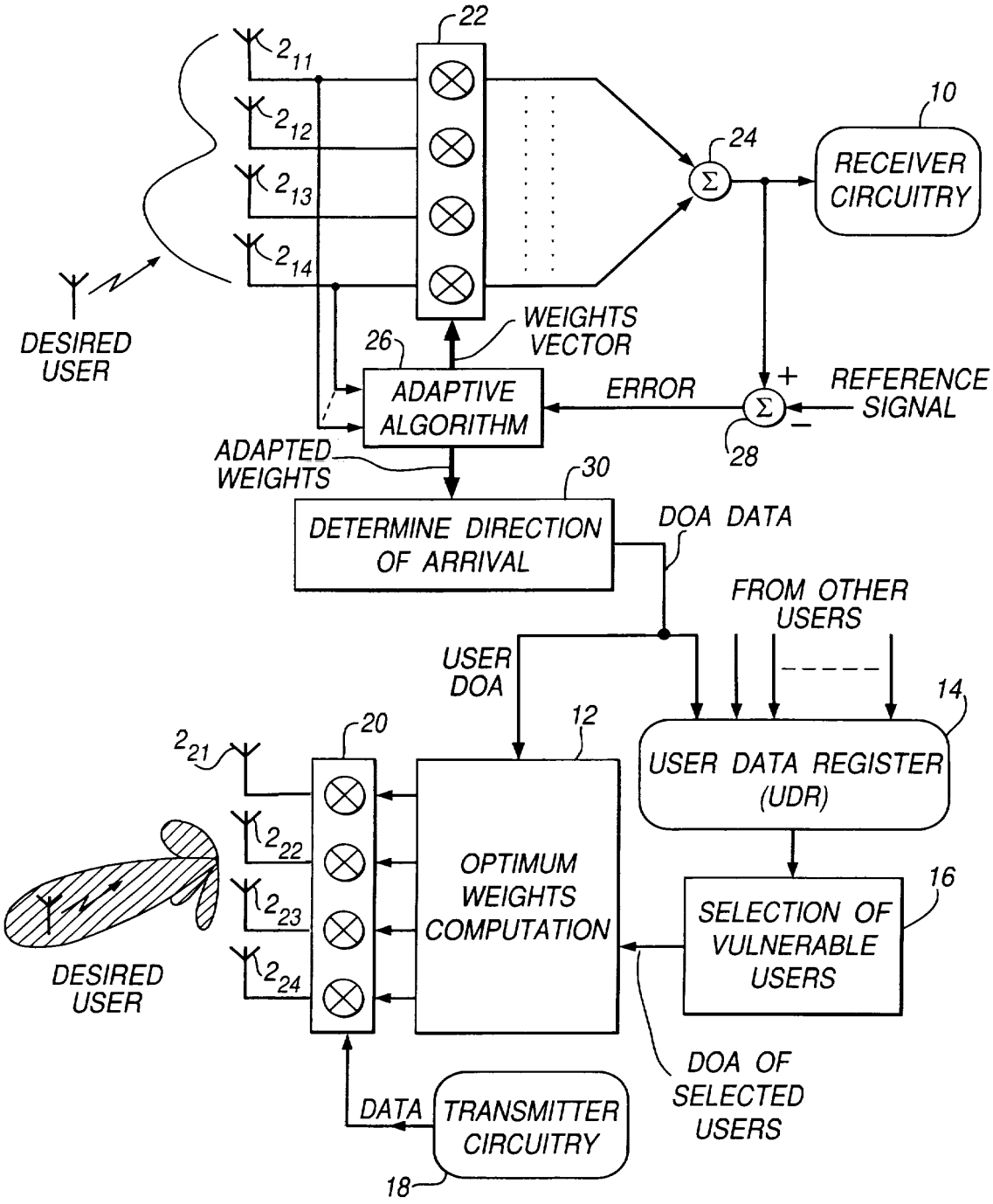
22
2_{11}
2_{12}
2_{13}
2_{14}
10
24
RECEIVER CIRCUITRY
DESIRED USER
WEIGHTS VECTOR
26
ADAPTIVE ALGORITHM
ERROR
+
REFERENCE SIGNAL
−
28
ADAPTED WEIGHTS
30
DETERMINE DIRECTION OF ARRIVAL
DOA DATA
FROM OTHER USERS
USER DOA
14
12
20
2_{21}
USER DATA REGISTER (UDR)
2_{22}
2_{23}
2_{24}
OPTIMUM WEIGHTS COMPUTATION
16
SELECTION OF VULNERABLE USERS
DESIRED USER
DOA OF SELECTED USERS
DATA
TRANSMITTER CIRCUITRY
18

Fig.2

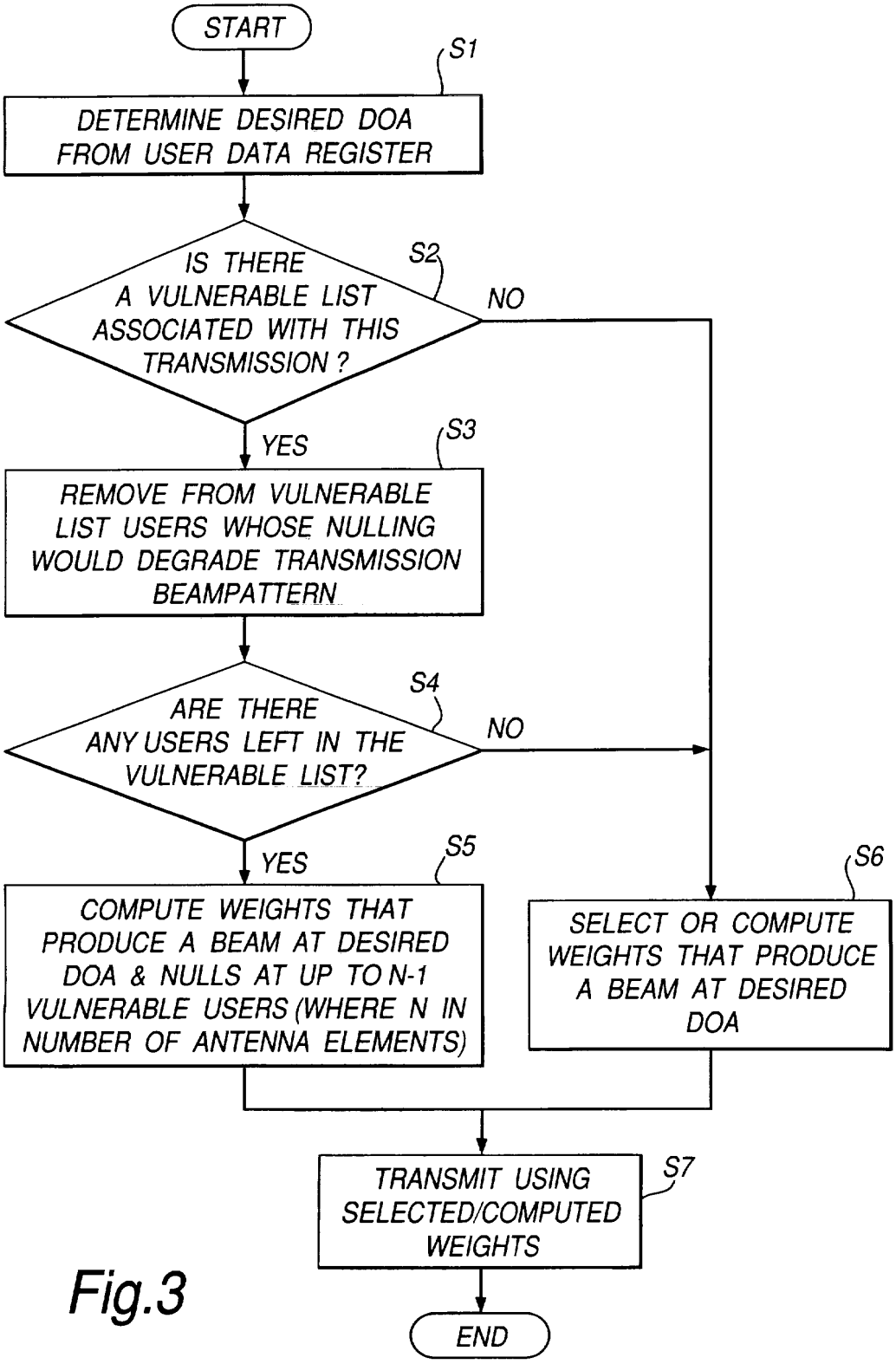
START
S1
DETERMINE DESIRED DOA FROM USER DATA REGISTER
S2
IS THERE A VULNERABLE LIST ASSOCIATED WITH THIS TRANSMISSION ?
NO
YES
S3
REMOVE FROM VULNERABLE LIST USERS WHOSE NULLING WOULD DEGRADE TRANSMISSION BEAMPATTERN
S4
ARE THERE ANY USERS LEFT IN THE VULNERABLE LIST?
NO
YES
S5
COMPUTE WEIGHTS THAT PRODUCE A BEAM AT DESIRED DOA & NULLS AT UP TO N-1 VULNERABLE USERS (WHERE N IN NUMBER OF ANTENNA ELEMENTS)
S6
SELECT OR COMPUTE WEIGHTS THAT PRODUCE A BEAM AT DESIRED DOA
S7
TRANSMIT USING SELECTED/COMPUTED WEIGHTS
END

Fig.3

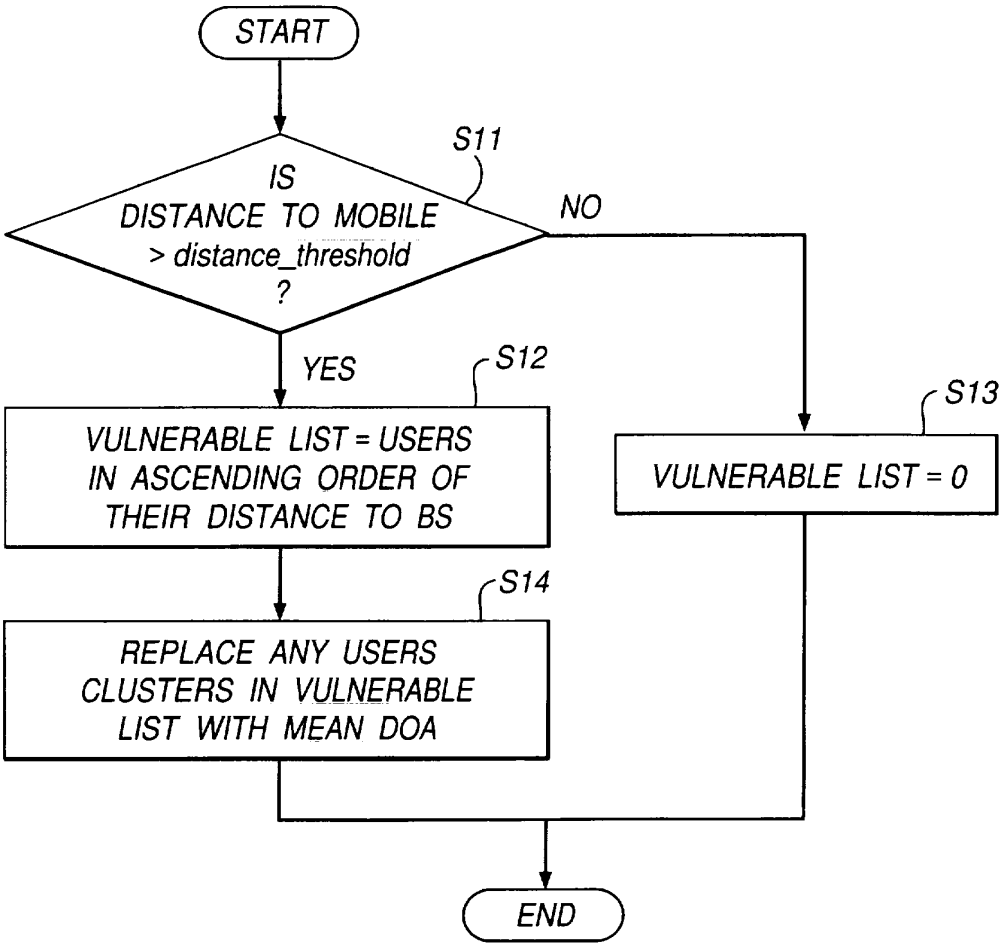
START
S11
IS
DISTANCE TO MOBILE
> distance_threshold
?
NO
YES
S12
VULNERABLE LIST = USERS
IN ASCENDING ORDER OF
THEIR DISTANCE TO BS
S13
VULNERABLE LIST = 0
S14
REPLACE ANY USERS
CLUSTERS IN VULNERABLE
LIST WITH MEAN DOA
END

Fig.4

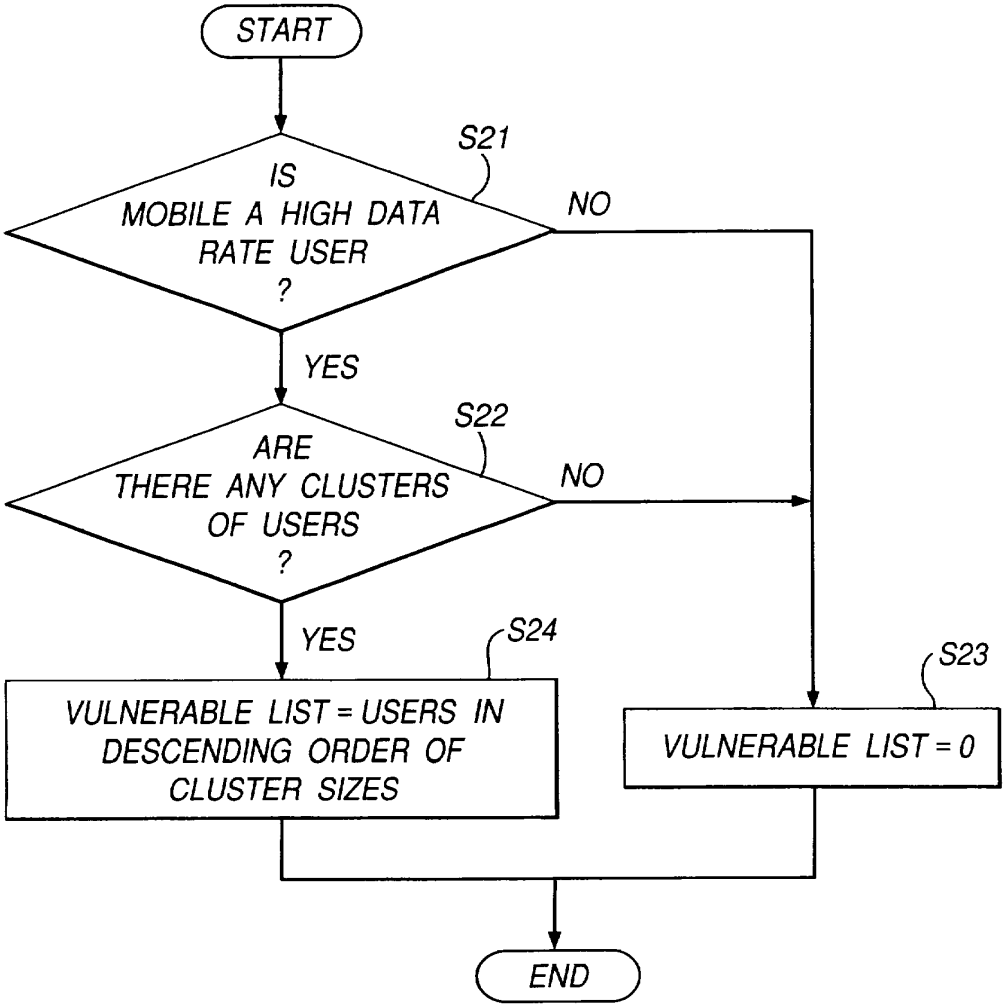

Fig.5

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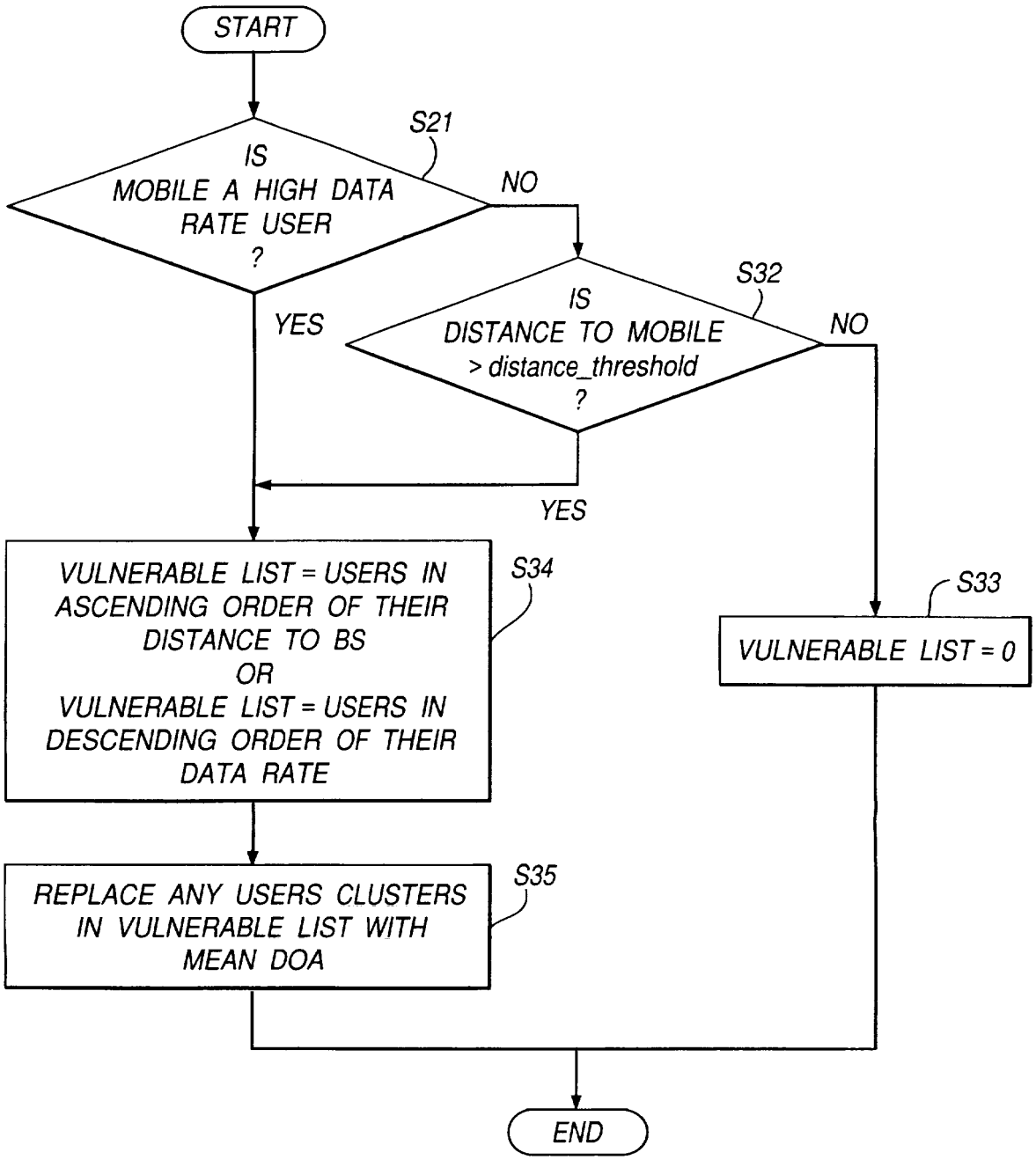
START
S21
IS MOBILE A HIGH DATA RATE USER ?
NO
YES
S32
IS DISTANCE TO MOBILE > distance_threshold ?
NO
YES
VULNERABLE LIST = USERS IN ASCENDING ORDER OF THEIR DISTANCE TO BS OR VULNERABLE LIST = USERS IN DESCENDING ORDER OF THEIR DATA RATE
S34
S33
VULNERABLE LIST = 0
REPLACE ANY USERS CLUSTERS IN VULNERABLE LIST WITH MEAN DOA
S35
END

Fig.6

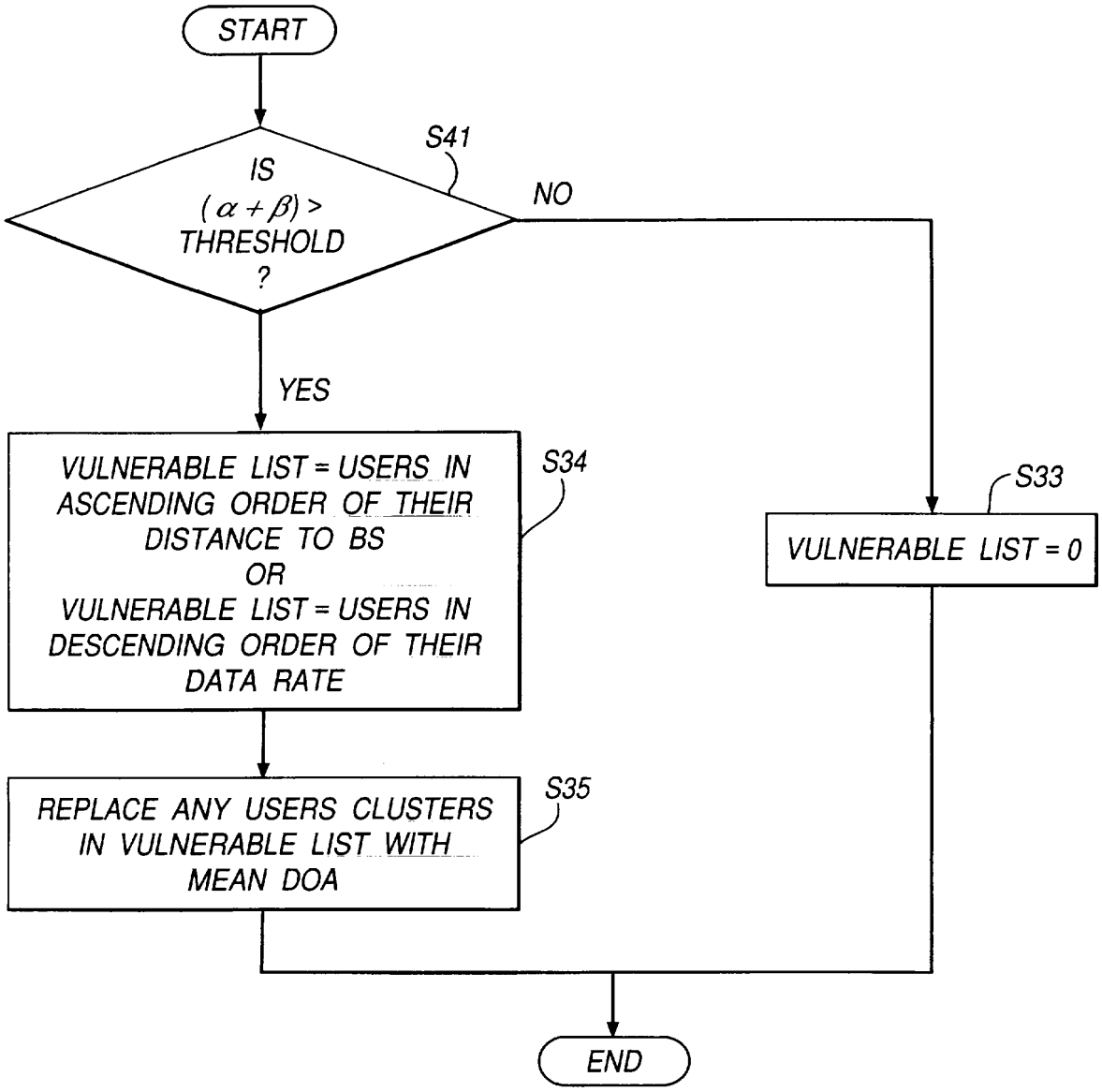
START
S41
IS
(α + β) >
THRESHOLD
?
NO
YES
VULNERABLE LIST = USERS IN ASCENDING ORDER OF THEIR DISTANCE TO BS
OR
VULNERABLE LIST = USERS IN DESCENDING ORDER OF THEIR DATA RATE
S34
S33
VULNERABLE LIST = 0
REPLACE ANY USERS CLUSTERS IN VULNERABLE LIST WITH MEAN DOA
S35
END

Fig.7

TRANSMISSION METHODS AND APPARATUS

The present invention relates to transmission methods and apparatus. In particular, but not exclusively, the present invention relates to transmission methods and apparatus for use in a base station of a cellular mobile communications system.

In a cellular mobile communications system, it is necessary for a base station to be able to detect uplink signals transmitted by a desired mobile station (user) to the base station and be able to transmit downlink signals back to that desired user.

A given desired user may be at any angular direction from the base station and a simple approach to transmission and detection of signals would be to transmit and "look for" all signals in all directions.

However, adaptive antennae techniques and beamforming techniques have been proposed for use in mobile communications systems such as the Universal Mobile Telecommunication System (UMTS). These techniques can provide improvements in performance and/or spectral efficiency of the system.

Most of the proposed adaptive antennae/beamforming techniques have been applied to reception of uplink signals at the base station. The principle underlying one such uplink beamforming technique is to process signals received from an adaptive antenna array at the base station to form a spatial beam pattern such that the angle of arrival of the uplink signal of a wanted user falls well within a main lobe of the beam pattern whereas interfering signals from other users are located as much as possible in the nulls, low side lobes or boundary regions of the main lobe.

However, as such uplink beamforming techniques improve, transmission of downlink signals from the base

station is becoming the system bottleneck. Downlink beamforming is one approach being considered to alleviate this potential bottleneck.

In Time Division Duplexing (TDD) systems, the channel between the desired user and the base station can be assumed to be the same for the uplink and the downlink. Therefore, if uplink beamforming is being performed, exactly the same beam pattern can be used for the downlink as in the uplink.

In Frequency Division Duplexing (FDD) systems the channel estimation performed in the uplink cannot be directly applied to the downlink. Due to the difference in frequency, there is no channel-impulse-response reciprocity between the uplink and the downlink. Beam reciprocity, however, does exist provided that the channel is substantially static between reception and transmission. Downlink beamforming can then be applied by simply pointing a beam in the user direction during transmission.

However, although such downlink beamforming approaches are expected to result in better performance than omnidirectional transmission, these approaches do not take into account the possible adverse affects on other users of the downlink signal transmission to a particular wanted user.

According to a first aspect of the present invention, there is provided a transmission method, for use in a mobile communications network, including the steps of: in a base station of the network, identifying, for a particular user of the network, one or more other mobile users that are to be treated as vulnerable users potentially adversely affected by a downlink signal transmission from the base station to the particular mobile user; determining a downlink beam pattern including a main beam having a direction matching a direction of the particular mobile user and

also including a null having a direction matching a direction of at least one of the said vulnerable users; and transmitting such a downlink signal to the said particular mobile user using the determined beam pattern.

Such a transmission method can form a more intelligent transmission beam pattern comprising a pointed beam and some nulls, the nulls being selected using user information available to the base station.

Incidentally, the term "matching", as used herein, does not require absolute equality of direction; only approximate equality is intended and some angular divergence is contemplated in practical systems.

In one embodiment the direction of the said particular mobile user and of the or each said vulnerable user is determined by processing an uplink signal received at the base station from the user concerned. Such a transmission method has the advantage that it makes use of information readily available in the base station.

Preferably, the said direction of the said particular mobile user and of the or each said vulnerable user is derived from an uplink beam pattern employed by the base station to process a received uplink signal from the user concerned. Such a transmission method has the advantage that it makes use of information readily available in the base station.

In one embodiment, the uplink beam pattern is adapted in use by the said base station; and an estimate of the direction of each said mobile user is derived from an adjustable weight vector corresponding to the uplink beam pattern determined for that user. Such a transmission method has the advantage that it makes use of information readily available in the base station.

Preferably, in the pattern determining step, any

identified vulnerable user whose direction would require the said downlink beam pattern to include such a null within, or near to, the said main beam is ignored. Such a transmission method has the advantage that the quality of the transmission to the desired user is not greatly degraded.

In one embodiment, the said downlink beam pattern is calculated based on the respective directions of the said particular mobile user and the or each said vulnerable user. Such a transmission method has the advantage that the locations of the peak and the nulls of the beam can be optimised.

Alternatively, in another embodiment, the determined downlink beam pattern is a best-matching downlink beam pattern selected from amongst a plurality of predetermined candidate downlink beam patterns. Such a transmission method has the advantage that the complexity of mathematical calculation required for each downlink signal to be transmitted is reduced.

One embodiment further includes an interference judging step of judging, for the said particular mobile user, whether, based on one or more predetermined criteria, the said downlink signal transmission to that user is likely to cause significant interference to other mobile users of the network and, if not, of omitting the said step of identifying vulnerable users and of determining the said downlink beam pattern for the particular mobile user independently of the effect of that transmission on other mobile users of the network. Such a transmission method has the advantage that complex calculation is avoided when it is not needed.

In this embodiment, preferably, the said one or more predetermined criteria used in the interference judging step relate exclusively to the particular mobile user. In this way, it can be determined

desirably simply whether or not it will be worthwhile identify vulnerable users.

The predetermined criteria used in the interference judging step may, for example, include one or more of the following:

a measure of the distance of the said particular mobile user from the base station; and a bit rate of the said downlink signal transmission to the said particular mobile user. Such information is readily available in the base station.

In one embodiment, in the said interference judging step it is judged that significant interference to other users is likely when a measure of the distance of the said particular mobile user from the base station exceeds a predetermined threshold value. This basis for judging interference is desirably simple but is effective because when the particular mobile user under consideration is relatively far from the base station the downlink transmission power to that user tends to be high, giving rise to significant interference to other users.

Alternatively, or in addition, in the interference judging step it may be judged that significant interference to other users is likely when a bit rate of the said particular mobile user exceeds a predetermined threshold value. This basis for judging interference is again simple but highly effective.

In one embodiment, in the step of identifying vulnerable users it is determined whether a mobile user other than the said particular mobile user is to be treated as a vulnerable user in dependence upon one or more of the following criteria:

the direction of that other mobile user; a measure of the distance of that other mobile user from the base station; a bit rate of that other mobile user; and a proximity of that other mobile user to further mobile

users of the network. Such a transmission method has the advantage of making use of information readily available in the base station.

Preferably, candidate mobile users other than the said particular mobile user are ranked in order of vulnerability according to the said criteria used in the identifying vulnerable users step and, when the number of other users exceeds the number N_{max} of nulls/low side lobes that it is possible to form in the said downlink beam pattern, the N_{max} most vulnerable candidate users in the said order are selected as vulnerable users for determining the downlink beam pattern. Such a ranking process is advantageous in environments where there are large numbers of mobile users, and permits identification of the most vulnerable users in a systematic manner.

In one embodiment, in the identifying vulnerable users step it is determined whether there are any clusters of other users and, if so, the clusters are ranked according to the numbers of users therein. Again, when there are large numbers of users in various clusters, this step enables the most vulnerable users to be prioritised so as to achieve the best overall result in terms of interference reduction.

In one embodiment, vulnerable users that form a cluster are processed collectively as a vulnerable cluster and the downlink beam pattern determined for the said particular mobile user is such as to include such a null having a direction matching a direction of the said vulnerable cluster. Such a collective processing method can enable the number of users for whom potential interference is reduced to be maximised, even when the total number of users exceeds the maximum number of possible nulls that can be formed.

The direction of the said vulnerable cluster may be determined based on an average of the respective

directions of the individual vulnerable users making up the cluster concerned. This average is easily calculable.

In one embodiment, the said distance measure for a mobile user is, or is derived from, a transmission power determined by the base station for transmitting a downlink signal to the user concerned. Such a transmission method has the advantage that it makes use of information already available in the base station in many networks.

Alternatively, the said distance measure for a mobile user may be, or may be derived from, a code time offset of an uplink signal received by the base station from the mobile user concerned. Such a transmission method has the advantage that it makes use of information already available in the base station in some networks.

Alternatively, the said distance measure for a mobile user and/or the said direction of a mobile user may be derived from information obtained using a satellite-based global positioning system (GPS). Such a transmission method has the advantage that the distance measures derived can be calculated with a great degree of accuracy. Some networks already use such a GPS based location system for emergency purposes.

Alternatively, in another embodiment, the said distance measure for a mobile user and/or the direction of a mobile user is derived from information obtained using triangulation techniques involving at least three base stations of the said network. Such a transmission method has the advantage that the distance measures derived can be calculated with a great degree of accuracy.

According to a second aspect of the present invention there is provided transmission apparatus, for

use in a base station of a mobile communications network, comprising: identification means operable to identify, for a particular mobile user of the network, one or more other mobile users that are to be treated as vulnerable users potentially adversely affected by a downlink signal transmission from the base station to the particular mobile user; determining means operable to determine a downlink beam pattern including a main beam having a direction matching a direction of the particular mobile user and also including a null having a direction matching a direction of at least one of the said vulnerable users; and transmission means operable to transmit such a downlink signal to the said particular mobile user using the determined beam pattern.

Such a transmission apparatus can form a more intelligent transmission beam pattern comprising a peak and some nulls, the peak and the nulls being selected using user information available to the base station.

In one embodiment, the apparatus further includes user data register means operable to store, for each of a plurality of mobile users of the said network, one or more predetermined items of information about the user concerned for use by the identification means to identify vulnerable users and/or by the determining means to determine the downlink beam pattern.

Such an apparatus has the advantage that required information about mobile users is stored in a readily accessible means.

In this embodiment, preferably, the stored items of information about each user include one or more of the following types of information: the direction of the mobile user; a measure of the distance of the mobile user from the base station; a bit rate of the mobile user; a position of the mobile user; and cluster information as to proximity of the mobile user to other

mobile users of the network. Such types of information about users are easily obtainable in the base station.

According to a third aspect of the present invention there is provided a base station for use in a mobile communications network, which includes transmission apparatus embodying the aforesaid second aspect of the present invention.

Such a base station can form a more intelligent transmission beam pattern comprising a peak and some nulls, the peak and the nulls being selected using user information available to the base station.

According to a fourth aspect of the present invention there is provided an angle-of-arrival calculation method, for use in receiving apparatus that includes an antenna array having a plurality of antenna elements for sampling, at different respective locations in space, a wanted signal transmitted to the apparatus and that also includes an adaptive beamformer operable to process a set of receive signals, derived respectively from the antenna elements of the array, in accordance with a beam pattern determined by an adjustable weight vector, the weight vector being adjusted in use of the apparatus in response to changes in an angle-of-arrival of the wanted signal at the antenna array, which method includes the steps of: processing the said adjustable weight vector to determine an angle-of-arrival of the wanted signal at which the response of the adaptive beamformer has a peak; and outputting a measure of angle-of-arrival of the said wanted signal based on the determined angle of peak beamformer response.

Such an angle-of-arrival calculation method can estimate the angle of arrival of an uplink signal from the uplink beam pattern without complex calculation.

Preferably, the said processing step comprises: determining the uplink beam pattern corresponding to

the current value of the said adjustable weight vector; calculating the uplink beamformer gain at a plurality of different possible angles-of-arrival according to the said uplink beam pattern; and selecting the angle-of-arrival for which the uplink beamformer gain is the greatest.

Such an angle-of-arrival calculation method can estimate the angle of arrival of an uplink signal from the uplink beam pattern without complex calculation.

Reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a block diagram of parts of a base station including transmission apparatus according to a first embodiment of the present invention;

Figure 2 is a block diagram of parts of a base station including transmission apparatus according to a second embodiment of the present invention;

Figure 3 is a flowchart illustrating an example of a transmission method for use in the apparatus of Figures 1 and 2;

Figure 4 is a flowchart of a process which may be used in a part of the apparatus of Figures 1 and 2;

Figure 5 is a flowchart of a second process which may be used in a part of the apparatus of Figures 1 and 2;

Figure 6 is a flowchart of a third process which may be used in a part of the apparatus of Figures 1 and 2; and

Figure 7 is a flowchart of a fourth process which may be used in a part of the apparatus of Figures 1 and 2.

A transmission method embodying the present invention seeks to optimise the transmission pattern for a particular mobile station by taking into account information on the other mobile stations within the

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system. In addition to forming a narrow beam in the direction of the desired user, nulls may also be placed in the direction of one or more other "vulnerable" users, i.e. users who are likely to be adversely affected by the downlink signal transmission to that desired user. The effect of this should be to reduce interference levels at these mobile units and hence improve the system's performance and capacity.

In systems having very few active users it may be possible to take into account all other users when setting the downlink beam pattern for a particular user. However, in most practical systems the number of active users will far exceed the number of users for which nulls can be formed, so in a preferred embodiment of the present invention, certain criteria are used to determine which mobile units are the most vulnerable to interference, and hence should have nulls in their directions during downlink transmission.

Alternatively, or in addition, certain criteria are used to determine whether the transmission to a given mobile unit is likely to cause interference and hence whether users vulnerable to interference need to be determined.

For example, generally speaking, when a base station transmits a downlink signal to a mobile station far away from the base station it transmits using a higher power level than for a mobile station close to the base station. Therefore a transmission from the base station to a far-away mobile station will cause more interference than a transmission to a nearby one. Also, a nearby mobile station, to which the base station is transmitting its downlink signal at a relatively low power, will be particularly adversely affected by a high-power transmission from the base station to a far-away mobile station since the nearby mobile station experiences a low signal-to-

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interference-and-noise ratio (SINR).

High-bit-rate (data rate) users are also more likely to cause and be affected by interference than low-bit-rate users. Therefore, in some types of system, for example a system with small cells that typically serve a large number of high-bit-rate users, bit rate could be used to select vulnerable users.

As an example, some of the following types of information about users might be used to determine vulnerable users: knowledge of the direction of arrival of signals from all users, knowledge of the relative distance of the users from the base station, knowledge of high-bit-rate users and knowledge of clusters of users.

In a base station in which beamforming is performed on the uplink, information about direction of arrival (DOA) of uplink signals from all the users within a given cell should be known to the base station.

Knowledge of the relative distance of users from the base station can be obtained using a number of methods. In one method, the relative distance from the base station of a given mobile unit can be estimated from a downlink transmission power determined for the mobile unit by the transmission power control (TPC) circuitry in the base station; the lower the transmitted power (TPC setting), the closer the mobile unit is assumed to be to the base station. As an alternative, code time offsets could be used to estimate the relative distances of the users from the base station.

Alternatively, a position location system may be used by the mobile communications system to obtain DOA and/or distance information for the users in the cell. This may involve a satellite-based global positioning system (GPS) or terrestrial triangulation techniques.

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For example, if the uplink signal from a mobile station is received by three base stations, then its exact location, and therefore DOA and distance from any of the base stations, can be calculated.

Data identifying high-bit-rate users is readily available at the base station and information about clusters of users is easily determined from DOA information available at the base station.

It will be appreciated that in many systems the number of available nulls in the transmission beam pattern will be insufficient to permit nulls to cover the vulnerable users individually, but in this situation providing a null corresponding to a cluster of users can still enable the overall system performance and capacity to be improved.

It should be noted that embodiments of the present invention are not restricted to the use of any one uplink beamforming technique.

Transmission apparatus according to a first embodiment of the present invention is illustrated in Figure 1, together with receiving apparatus capable of performing multibeam uplink beamforming.

The receiving apparatus comprises a first array of antenna elements 2_{11} to 2_{14} connected via respective down-converters (not shown) to a multiple vector multiplier unit 4. The multiple vector multiplier unit 4 comprises M sets of complex-conjugate multipliers, where M (= 4 in this embodiment) is the number of different trial (uplink) beam patterns formed by the receiving apparatus. Each of the M sets of multipliers has N multipliers, where N (= 4 in this embodiment) is the number of antenna elements in the first array. Each of the M sets of multipliers has a corresponding uplink weight vector associated with it for defining the trial beam pattern with which it is to process the receive signals produced by the antenna elements 2_{11} to

2_{14}. It should be noted that the values of N and M do not have to be 4 and can be different from each other.

The multiple vector multiplier unit 4 is in turn connected, via a set of combiners 6_1 to 6_4, to a beam selector 8.

The receiving apparatus also comprises receiver circuitry 10 connected to an output of the beam selector 8.

The transmission apparatus comprises a user data register (UDR) 14, an optimum weights computation unit 12 and a vulnerable users selection unit 16.

The UDR 14 has a plurality of data inputs connected to other parts of the base station for receiving therefrom data signals corresponding to each user. These data signals include a user DOA signal corresponding to each user produced by the beam selector 8 in the receiving apparatus. The user DOA signal for the desired user is also passed to the optimum weights computation unit 12. The vulnerable users selection unit 16 has an input connected to the UDR 14 and an output connected to the optimum weights computation unit 12.

The Figure 1 apparatus further comprises transmitter circuitry 18, a downlink beamformer 20 and a second array of antenna elements 2_{21} to 2_{24}. The downlink beamformer 20 comprises P complex-conjugate multipliers, where P (= 4 in this embodiment) is the number of antenna elements in the second array. P need not be the same as N, although this may be preferable for simplifying the processing required.

Each multiplier in the downlink beamformer 20 is connected to receive one of a set of P weight values, making up a weight vector, from the optimum weights computation unit 12 and is also connected to receive from the transmitter circuitry 18 data to be transmitted to the desired user. Each multiplier in

the downlink beamformer 20 produces a transmit signal, which is applied to a corresponding one of the antenna elements 2_{21} to 2_{24} of the second array.

Operation of the Figure 1 apparatus will now be described. In use, the multiple vector multiplier unit 4, the set of combiners 6_1 to 6_4 and the beam selector 8 together serve as a multibeam uplink beamformer. To receive an uplink signal from a particular desired user each set of multipliers in the multiple weight vectors unit multiplies the receive signals, produced respectively by the first-array antenna elements 2_{11} to 2_{14}, by its associated uplink weight vector, each uplink weight vector corresponding to a different preselected trial uplink beam pattern. The uplink beam patterns have, for example, different beam directions covering a particular sector of the base station. The partial products of the multiplication are summed in the combiners 6_1 to 6_4 to produce output signals corresponding respectively to the trial beam patterns. The beam selector 8 compares the output signals and selects the best trial beam pattern for detecting the uplink signal from the present desired user. Alternatively, instead of selecting just one best beam pattern, the beam selector 8 may perform an interpolation operation to derive a further weight vector corresponding to a beam pattern having a direction between two or more comparably-good different trial beam patterns. The result of this selection/interpolation is output to the receiver circuitry 10, which uses the output signal for the best trial beam pattern directly to perform signal reception on the uplink signals from the desired user.

The beam selector 8 outputs a user DOA signal which, in this embodiment, simply provides the identity of the selected best uplink beam pattern or, if interpolation is used, the identities of the best

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uplink beam patterns. This user DOA signal effectively defines an expected DOA of uplink signals from the particular desired user. This user DOA signal is output to the UDR 14 and the optimum weights computation unit 12 in the transmission apparatus.

The UDR 14 stores predetermined types of information about each user. In this embodiment, the UDR stores the DOA, the power level and the bit rate each user is operating at. This information is regularly updated for example, every frame, or every timeslot within a frame, or dynamically at intervals determined by operating parameters of the apparatus.

In the vulnerable users selection unit 16, the user information stored in the UDR 14 is used to determine one or more of the following: the DOA information for the desired user, users nearest to the base station, users who are close to clusters of other users, and users who are close to high bit rate users. Then, using suitable criteria, that information can be used to generate a list of vulnerable users associated with every user. Different examples of criteria which can be used to generate a list of vulnerable users will be described in detail hereinbelow with reference to Figures 4, 5, 6 and 7. It should be noted that the criteria used may be fixed or made dynamic and may vary depending on the particular environment or scenario. For example, in environments where there is a high proportion of high-bit-rate users or clusters of high-bit-rate users, the criteria for determining vulnerable users might advantageously be to minimise the adverse effect on/of these high-bit-rate users / user clusters. On the other hand, in cells whose range is extended, the distance between the users and the base station becomes an important criterion.

Once the list of vulnerable users associated with the desired user has been generated in the vulnerable

users selection unit 16, the DOA of each vulnerable user is output to the optimum weights computation unit 12.

The optimum weights computation unit 12 calculates a set of weights defining a downlink beam pattern which has its main lobe in the direction of the desired user and preferably has nulls in the directions of some or all of the most vulnerable users. It should be noted that however vulnerable the corresponding user, a null should not be placed in the main beam of the beam pattern as this would degrade the downlink beam pattern. It should also be noted that for an array of N elements, it is mathematically possible to form up to N-1 nulls. Therefore, in this embodiment in which there are 4 elements in the second array of antenna elements 2_{21} to 2_{24}, the maximum number of nulls which can be formed at any time is 3.

Once the weights have been calculated by the optimum weights computation unit 12, these are multiplied, in the downlink beamformer 20, with the data to be transmitted to the desired user received from the transmitter circuitry 18. The resulting transmit signals are then transmitted via the second array of antenna elements 2_{21} to 2_{24}.

It will be appreciated that the first and second arrays of antenna elements in the Figure 1 base station do not have to be physically distinct. One physical array of antenna elements could serve, in any of, for example, a time-division-multiplexed, frequency-division-multiplexed or code-division-multiplexed fashion, both for uplink reception and downlink transmission purposes.

Figure 2 is a block diagram illustrating parts of a base station according to a second embodiment of the present invention. In this embodiment, adaptive uplink beamforming is implemented. Components of the Figure 2

apparatus which correspond to components already described with reference to Figure 1 will be denoted by the same reference numerals.

In place of the multiple vector multiplier unit 4, the set of combiners 6_1 to 6_4 and the beam selector 8 used in the receiving apparatus of the first embodiment, receiving apparatus in the second embodiment comprises a vector multiplier 22, a combiner 24, an adaptive algorithm unit 26, and an adder 28. The vector multiplier 22 includes complex-conjugate multipliers equal in number to the antenna elements of the first array. The vector multiplier 22 has four signal inputs, corresponding respectively to the antenna elements 2_{11} to 2_{14}, and a weight vector input coupled to an output of the adaptive algorithm unit 26. The signal outputs of the vector multiplier 22 are coupled to respective inputs of the combiner 24. An output of the combiner 24 is connected both to the receiver circuitry 10 and to a positive input of the adder 28. The adder 28 also has a negative input at which it receives a reference signal. An error signal produced at an output of the adder 28 is coupled to an input of the adaptive algorithm unit 26. The adaptive algorithm unit 26 has further signal inputs connected to the first array of antenna elements 2_{11} to 2_{14}.

In the Figure 2 embodiment the transmission apparatus further comprises a DOA determining unit 30 having a weight vector input connected to the adaptive algorithm unit 26. A user DOA signal produced at an output of the DOA determining unit 30 is coupled to inputs of the UDR 14 and the optimum weights computation unit 12.

Operation of the Figure 2 apparatus will now be described. In use, the vector multiplier 22, the combiner 24, the adder 28 and the adaptive algorithm unit 26 together serve as an adaptive uplink

beamformer. In the vector multiplier 22 receive signals derived from the antenna elements 2_{12} to 2_{14} are multiplied by corresponding weights of a variable weight vector supplied by the adaptive algorithm unit 26. This variable weight vector defines an adaptable uplink beam pattern for use by the receiving apparatus to process the receive signals. The partial products output by the vector multiplier 22 are summed together by the first combiner 24 and the result is output to the receiver circuitry 10 which performs signal detection. The output of the combiner 24 is compared with a reference signal using the adder 28. This reference signal is, for example, generated based on the received uplink signals after detection by the receiver circuitry 10. The resulting error signal produced by the adder 28 is fed back to the adaptive algorithm unit 26 as an indication of how good the current weight vector is. The adaptive algorithm unit 26 uses an adaptive algorithm to update the variable weight vector.

The updated weight vector is also output to the DOA determining unit 30. Assuming the adaptive algorithm used in the adaptive algorithm unit 26 is fairly stable, an estimate of the DOA of the desired user can be derived from the weight vector corresponding to the uplink beam pattern determined for that user. This could be done, for example, by finding the peak of the uplink beam pattern (e.g. by calculating the uplink beamformer gain at different DOAs and identifying the DOA for which the gain is the highest). This DOA estimate is stored at the UDR 14 in an entry therein corresponding to the desired user.

Figure 3 is a flowchart showing a sequence of steps for transmitting a downlink signal to one desired user in an embodiment of the present invention.

In step S1, the last-known DOA of the desired user

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is determined using data stored in the UDR in response to reception of a preceding uplink signal from that user.

Then, in step S2, it is determined whether there is a list of vulnerable users (vulnerable list) associated with the transmission to the desired user. Methods for producing such a vulnerable list will be described in detail with reference to Figures 4, 5, 6 and 7. If there is a vulnerable list associated with the transmission, then step S3 is executed. If, on the other hand, the vulnerable list is empty, control moves to step S6.

In step S3 any users in the vulnerable list for whom the provision of a null in the downlink beam pattern for the desired user would degrade that pattern unduly are removed from the vulnerable list. One possible way of doing this is to compare the DOA of each user in the vulnerable list with the DOA of the desired user. If the DOA of a user in the vulnerable list falls within a certain angular range of the DOA of the desired user, then a null corresponding to this vulnerable user would fall within a main beam of the downlink beam pattern. Such a null would degrade the transmission pattern and therefore this user should be removed from the vulnerable list. It will be noted that the required angular separation between the main beam and a null may be determined by the beam width of the main beam which can be calculated as a function of the number of elements and the inter-element spacing. In an embodiment of the present invention this might work out as approximately 10°.

Then, in step S4, it is determined whether there are any users left in the vulnerable list. If there are, control moves to step S5. If not, control moves to step S6.

In step S5, weights are computed (or suitable

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weights are selected from amongst a set of predetermined weights) which will generate a downlink beam pattern comprising a main beam in the direction of the desired user and nulls in the directions of up to N-1 vulnerable users (where N is the number of antenna elements). If there are more than N-1 vulnerable users in the vulnerable list, the N-1 most vulnerable users can be selected. To this end, as described later with reference to Figures 4 to 7, the users in the vulnerable list are preferably sorted into descending order of vulnerability in the vulnerable users selection unit 16, and then the first N-1 users in the list are selected.

Any suitable technique or algorithm can be used to compute the appropriate weights based on the DOA information for the desired user and the vulnerable users. Examples of possible techniques can be found in a paper by B. Van Veen and K. Buckley entitled "Beamforming: a versatile approach to spatial filtering" IEEE ASSP Magazine, April 1988, pp. 4 - 24, and also in a book by J. Hudson entitled "Adaptive Array Principles" published by Peter Peregrinus Ltd, London, 1981. When calculating the weights, using one of these techniques, appropriate constraints are used to achieve a main beam directed at the desired user and some of the nulls in the directions of some of the most vulnerable users.

Theoretically, an N element array can generate up to N-1 nulls. However, the locations of the nulls have to be outside the main beam to prevent its distortion. The allowed locations of the nulls are dependent on the array resolution, which in turn is influenced by the number of elements in the antenna array.

As mentioned above, the required weights can alternatively be selected from a set of available weights. In this case it is possible to select, as

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appropriate weights, weights which produce a downlink beam pattern whose natural nulls correspond to the DOAs of at least some of the vulnerable users without significantly mis-pointing the main beam.

In step S6, which is executed if the vulnerable list is empty, according to either step S2 or step S4, weights are selected or computed that produce a beam pattern having a main beam directed in the desired user's determined uplink DOA, without reference to other users.

After each of steps S5 and S6, step S7 is executed. In step S7, data is transmitted to the desired user using the weights selected/computed according to step S5 or step S6.

Figures 4, 5, 6 and 7 are flowcharts illustrating how different criteria can be used for the selection of vulnerable users in the selection of vulnerable users unit 16 of Figures 1 and 2. The used criterion (criteria) will depend on the particular application and environment, and may change as the environment changes.

In the examples of Figures 4, 5, 6 and 7, the vulnerable list for a particular desired user is constructed in two stages prior to a downlink signal transmission to that user.

The first stage is to determine whether the downlink signal transmission concerned could cause excessive interference to other users. In this stage, based on certain criteria, a decision is made as to whether there could be some users who are vulnerable to the current transmission. If the decision in the first stage is that the transmission is unlikely to cause adverse effects to other users, then there is no need for any further processing and the vulnerable list = 0 (i.e. is empty). However, if it is decided in the first stage that there could be other vulnerable users,

the second stage is to construct the vulnerable list, that is a list of users that could be adversely affected by the current transmission. Certain criteria, which may be the same or different from those used in the first stage, are used to determine the degree of vulnerability of every user to the transmission to the desired user, and the users considered vulnerable are listed in the vulnerable list in descending order of vulnerability.

Figure 4 is a flowchart illustrating distance-based selection of vulnerable users. This might be suitable for cells with large coverage areas where different mobile users could experience significantly different path losses.

In step S11 it is determined whether the distance from the base station to the desired user's mobile station is greater than a predetermined distance threshold. If it is not, the transmission to that mobile station is unlikely to adversely affect other users, since the transmission will be at a relatively low power, and control moves to step S13 in which the vulnerable list is set to an empty state (vulnerable list = 0) whereupon processing ends.

If the desired user's mobile station's distance from the base station is greater than the distance threshold, however, control moves to S12. In step S12, the vulnerable list is formed as a list of all other users sorted in ascending order of their distance to the base station.

Then, in step S14, any users in the vulnerable list which belong to a cluster (i.e. are located near one another) are identified. This could be done, for example, by comparing the distances and DOAs of the users in the vulnerable list. Entries in the list for those users which belong to a cluster are replaced by a "cluster" entry in the list that has its DOA set equal

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to the mean DOA of cluster concerned. This makes it possible to form nulls in the respective DOAs of the clusters.

Figure 5 is a flowchart illustrating bit-rate based selection of vulnerable users. This might be suitable for small cells that typically serve a significant number of high data/bit rate users.

In step S21, it is determined whether the desired user is a high data rate user. The data rate a given user is operating at is readily available to the base station, so this can be done simply by setting a threshold data rate above which a user is considered to be a high data rate user.

If the user is not a high data rate user then control moves to step S23. In step S23 the vulnerable list is set to the empty state and processing ends.

If, however, the desired user is a high data rate user according to step S21 control moves to step S22. In step S22 it is determined whether there are any clusters of users. If there are not any clusters of users then control moves to step S23 where the vulnerable list is also set to the empty state.

In this embodiment only if there is a high bit rate user and there is at least one cluster of users, who may be but are not necessarily high-bit-rate users, then, in step S24 entries are made in the vulnerable list for the clusters in descending order of cluster sizes. As before, the entry for each cluster has its DOA set to the mean DOA of the users in the cluster concerned.

Figure 6 is a flowchart illustrating a combined bit rate and distance based selection of vulnerable users. This might be suitable for large cells with a large number of high bit rate users.

In step S31 it is determined whether the desired user is a high data rate user. If so, then control

moves to step S34. If not, then control moves to step S32.

In step S32 it is determined whether the distance from the base station to the desired user mobile is greater than a predetermined distance threshold. If it is, then, as in S31, control moves to step S34. If it is not, control moves to step S33.

Thus, in this embodiment it is decided to form a vulnerable list when the desired user is a high data rate user or further than the distance threshold from the base station.

In step S33, which is executed when the desired user is neither a high data rate user nor further from the base station than the distance threshold, the vulnerable list is set to the empty state and processing ends.

In step S34, in one implementation, the vulnerable list is set equal to a list of all other users sorted in ascending order of their distance from the base station. In another implementation, the vulnerable list is set equal to a list of all other users in descending order of their data rates. If desired, the users in the vulnerable list may be sorted according to a combination of the distance and data rate criteria.

Then, in step S35, entries for users in the vulnerable list that belong to a cluster are replaced by a cluster entry whose DOA is set equal to the mean DOA of the users in the cluster concerned.

Figure 7 is a flowchart illustrating a modification of the process of selecting vulnerable users according to Figure 6. Steps in the Figure 7 flowchart which correspond to steps already described with reference to Figure 6 will be denoted by the same reference numerals.

This modified selection process applies a weighting process to the desired user's data rate and

distance from the base station and combines the results of the weightings to form a measure of the desired user's potential adverse effect on other users. Weightings α and β for a desired user could be calculated as follows:

$$\alpha = \frac{\text{Desired User's Data Rate}}{\text{Data Rate Threshold}} \quad (1)$$

$$\beta = \frac{\text{Desired User's Distance to Base Station}}{\text{Distance Threshold}} \quad (2)$$

In step S41, the weightings α and β are summed and the measure $\alpha+\beta$ is used to determine whether it is necessary to protect any vulnerable users from a downlink transmission to the desired user. The value of a threshold for the measure $\alpha+\beta$ could be set appropriately at the base station. According to step S41, if the measure $\alpha+\beta$ is greater than the threshold value then control moves to steps S34 and S35, which were described hereinbefore with reference to Figure 6. If the measure $\alpha+\beta$ is less than the threshold value then control moves to step S33, which is also described hereinbefore with reference to Figure 6.

CLAIMS:

1. A transmission method, for use in a base station of a mobile communications network, including the steps of:

identifying, for a particular mobile user of the network, one or more other mobile users that are to be treated as vulnerable users potentially adversely affected by a downlink signal transmission from the base station to the particular mobile user;

determining a downlink beam pattern including a main beam having a direction matching a direction of the particular mobile user and also including a null having a direction matching a direction of at least one of the said vulnerable users; and

transmitting such a downlink signal to the said particular mobile user using the determined beam pattern.

2. A method as claimed in claim 1, wherein the said direction of the said particular mobile user and of the or each said vulnerable user is determined by processing an uplink signal received at the base station from the user concerned.

3. A method as claimed in claim 1 or 2, wherein the said direction of the said particular mobile user and of the or each said vulnerable user is derived from an uplink beam pattern employed by the base station to process a received uplink signal from the user concerned.

4. A method as claimed in claim 3, wherein

the uplink beam pattern is adapted in use by the said base station; and

an estimate of the direction of each said mobile user is derived from an adjustable weight vector corresponding to the uplink beam pattern determined for that user.

5. A method as claimed in any preceding claim, wherein, in the pattern determining step, any identified vulnerable user whose direction would require the said downlink beam pattern to include such a null within, or near to, the said main beam is ignored.

6. A method as claimed in any preceding claim, wherein the said downlink beam pattern is calculated based on the respective directions of the said particular mobile user and the or each said vulnerable user.

7. A method as claimed in any one of claims 1 to 5, wherein the determined downlink beam pattern is a best-matching downlink beam pattern selected from amongst a plurality of predetermined candidate downlink beam patterns.

8. A method as claimed in any preceding claim, further including an interference judging step of judging, for the said particular mobile user, whether, based on one or more predetermined criteria, the said downlink signal transmission to that user is likely to cause significant interference to other mobile users of the network and, if not, of omitting the said step of identifying vulnerable users and of determining the said downlink beam pattern for the particular mobile user independently of the effect of that transmission on other mobile users of the network.

9. A method as claimed in claim 8, wherein the said one or more predetermined criteria used in the interference judging step relate exclusively to the particular mobile user.

10. A method as claimed in claim 8 or 9, wherein the said predetermined criteria used in the interference judging step include one or more of the following:

a measure of the distance of the said particular mobile user from the base station; and a bit rate of the said downlink signal transmission to the said particular mobile user.

11. A method as claimed in any one of claims 8 to 10, wherein in the said interference judging step it is judged that significant interference to other users is likely when a measure of the distance of the said particular mobile user from the base station exceeds a predetermined threshold value.

12. A method as claimed in any one of claims 8 to 11, wherein in the interference judging step it is judged that significant interference to other users is likely when a bit rate of the said particular mobile user exceeds a predetermined threshold value.

13. A method as claimed in any preceding claim, wherein in the step of identifying vulnerable users it is determined whether a mobile user other than the said particular mobile user is to be treated as a vulnerable user in dependence upon one or more of the following criteria:

the direction of that other mobile user, a measure of the distance of that other mobile user from the base station; a bit rate of that other mobile user; a bit rate of that other mobile user; and a proximity of that other mobile user to further mobile users of the network.

14. A method as claimed in claim 13, wherein candidate mobile users other than the said particular mobile user are ranked in order of vulnerability according to the said criteria used in the identifying vulnerable users step and, when the number of other users exceeds the number N_{max} of nulls/low side lobes that it is possible to form in the said downlink beam pattern, the N_{max} most vulnerable candidate users in the said order are selected as vulnerable users for

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determining the downlink beam pattern.

15. A method as claimed in any preceding claim, wherein in the identifying vulnerable users step it is determined whether there are any clusters of other users and, if so, the clusters are ranked according to the numbers of users therein.

16. A method as claimed in any preceding claim, wherein vulnerable users that form a cluster are processed collectively as a vulnerable cluster and the downlink beam pattern determined for the said particular mobile user is such as to include such a null having a direction matching a direction of the said vulnerable cluster.

17. A method as claimed in claim 16, wherein the direction of the said vulnerable cluster is determined based on an average of the respective directions of the individual vulnerable users making up the cluster concerned.

18. A method as claimed in claim 10 or 13, wherein the said distance measure for a mobile user is, or is derived from, a transmission power determined by the base station for transmitting a downlink signal to the user concerned.

19. A method as claimed in claim 10 or 13, wherein the said distance measure for a mobile user is, or is derived from, a code time offset of an uplink signal received by the base station from the mobile user concerned.

20. A method as claimed in claim 10 or 13, wherein the said distance measure for a mobile user and/or the said direction of a mobile user is derived from information obtained using a satellite-based global positioning system.

21. A method as claimed in claim 10 or 13, wherein the said distance measure for a mobile user and/or the direction of a mobile user is derived from information obtained using triangulation techniques involving at least three base stations of the said network.

22. Transmission apparatus, for use in a base station of a mobile communications network, comprising:

identification means operable to identify, for a particular mobile user of the network, one or more other mobile users that are to be treated as vulnerable users potentially adversely affected by a downlink signal transmission from the base station to the particular mobile user;

determining means operable to determine a downlink beam pattern including a main beam having a direction matching a direction of the particular mobile user and also including a null having a direction matching a direction of at least one of the said vulnerable users; and

transmission means operable to transmit such a downlink signal to the said particular mobile user using the determined beam pattern.

23. Apparatus as claimed in claim 22, further including:

user data register means operable to store, for each of a plurality of mobile users of the said network, one or more predetermined items of information about the user concerned for use by the identification means to identify vulnerable users and/or by the determining means to determine the downlink beam pattern.

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24. Apparatus as claimed in claim 23, wherein the stored items of information about each user include one or more of the following types of information: the direction of the mobile user; a measure of the distance of the mobile user from the base station; a bit rate of the mobile user; a position of the mobile user; and cluster information as to proximity of the mobile user to other mobile users of the network.

25. A base station for use in a mobile communications network, including transmission apparatus as claimed in any one of claims 22 or 24.

26. An angle-of-arrival calculation method, for use in receiving apparatus that includes an antenna array having a plurality of antenna elements for sampling, at different respective locations in space, a wanted signal transmitted to the apparatus and that also includes an adaptive beamformer operable to process a set of receive signals, derived respectively from the antenna elements of the array, in accordance with a beam pattern determined by an adjustable weight vector, the weight vector being adjusted in use of the apparatus in response to changes in an angle-of-arrival of the wanted signal at the antenna array, which method includes the steps of:

processing the said adjustable weight vector to determine an angle-of-arrival of the wanted signal at which the response of the adaptive beamformer has a peak; and

outputting a measure of angle-of-arrival of the said wanted signal based on the determined angle of peak beamformer response.

27. A method as claimed in claim 26, wherein the said processing step comprises:

determining the uplink beam pattern corresponding to the current value of the said adjustable weight vector;

calculating the uplink beamformer gain at a plurality of different possible angles-of-arrival according to the said uplink beam pattern; and

selecting the angle-of-arrival for which the uplink beamformer gain is the greatest.

28. A transmission method substantially as hereinbefore described with reference to the accompanying drawings.

29. Transmission apparatus substantially as hereinbefore described with reference to the accompanying drawings.

30. A base station substantially as hereinbefore described with reference to the accompanying drawings.

31. An angle-of-arrival calculation method substantially as hereinbefore described with reference to the accompanying drawings.

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Application No: GB 9908839.5 **Examiner:** M J Billing
Claims searched: 1 to 25 **Date of search:** 16 September 1999

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UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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Other: ONLINE - EPODOC, WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2328800A	(MOTOROLA) - Figs.2,3; page 4 line 1 to page 5 line 11	1,2,6,13, 22 at least
X	GB2318947A	(MOTOROLA) - page 12 lines 9-20, page 13 lines 19-26, page 14 line 20 to page 15 line 28	1,2,6,13, 22 at least
X	GB2316807A	(MATSUSHITA) - Figs.52,53; Abstract, page 18 lines 8-21, page 94 line 16 to page 97 line 7	1,2,6,13, 22 at least
X	GB2307142A	(MOTOROLA) - page 5 lines 3-20, page 6 lines 8-18	1,2,13,21, 22 at least
X	EP0841827A2	(LUCENT) - page 6 lines 8-21, page 11 line 37 to page 18 line 22	1,2,6,13, 22 at least
X,E	WO99/22423A1	(ERICSSON) - Fig.3; page 5 lines 5-8, page 7 lines 9-27, page 9 lines 17-21	1,2,6,13, 22 at least
X	WO98/16077A2	(TERATECH) - page 13 lines 20-23, page 17 line 17 to page 18 line 7	1,2,6,13, 20,22 at least

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INVESTOR IN PEOPLE

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Category	Identity of document and relevant passage		Relevant to claims
X	US5260968	(GARDNER) - column 6 lines 17-26, column 13 lines 3-44	1,2,6,13, 22 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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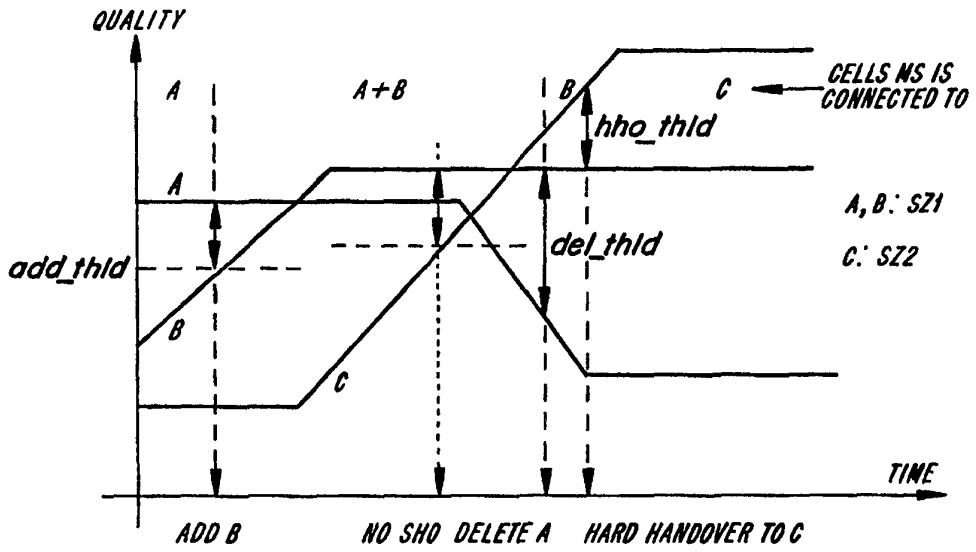

(57) Abstract

A method, controller and system for controlling handoffs in radio communication systems using a softzone concept are described. Soft handoff is permitted between members of a particular softzone, but not between members of different softzones. Hard handoff is permitted between members of different softzones, but not between members of the same softzone.

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METHODS AND SYSTEMS FOR CONTROLLING HARD AND SOFT HANDOFFS IN RADIO COMMUNICATION SYSTEMS

BACKGROUND

The present invention relates generally to methods and systems for radiocommunications and, more particularly, to such systems in which a connection can be handed over from one channel or base station to another.

The cellular telephone industry has made phenomenal strides in commercial operations in the United States as well as the rest of the world. Growth in major metropolitan areas has far exceeded expectations and is rapidly outstripping system capacity. If this trend continues, the effects of this industry's growth will soon reach even the smallest markets. Innovative solutions are required to meet these increasing capacity needs as well as maintain high quality service and avoid rising prices.

In cellular systems, the capability is typically provided to transfer handling of a connection between, for example, a mobile station and a base station to another base station, as the mobile station changes its position and so moves out of the coverage area of one base station and into the coverage area of another base station. This type of handoff is commonly referred to as an "intercell" handoff as the coverage areas associated with base stations are commonly referred to as "cells". Depending upon the quality of the current channel, it may also be desirable to transfer a connection from one channel of the base station to another channel supported by the same base station, which handoffs are commonly referred to as "intracell" handoffs.

So-called "hard" handoffs refer to handoffs which are performed wherein there is no overlap in time between transmissions received from an original, serving base station and transmissions received from a new, target base station. As shown in Figure 1(a), during hard handoff, the mobile station (MS) typically first breaks its connection to its original base station (BTS1) and then establishes a connection to its new base station (BTS2).

By way of contrast, "soft" handoffs refer to handoffs wherein, for some period of time, a mobile station receives substantially the same information from two (or more) transmission sources. An exemplary soft handoff scenario is illustrated in Figure 1(b). Therein, before starting soft handoff, the MS is connected to BTS1. During the soft handoff, the MS establishes a connection to BTS2 without dropping the connection to BTS1. Each base station which is concurrently communicating with a particular mobile station may be referred to as a member of that mobile station's "active set". At some time after the connection to BTS2 is set up, the connection to BTS1 will be released which is the termination of the soft handover procedure. The overlapping transmissions from BTS1 and BTS2 permit the mobile station to smoothly switch from receiving information from its original, serving base station to receiving information from its new, target base station. During soft handoff, the mobile station may also take advantage of the fact that it is receiving substantially the same information from two sources to improve its received signal quality by performing diversity selection/combining of the two received signals.

For the sake of simplicity, the foregoing examples of the hard and soft handoff were described in the context of base stations employing omnidirectional antennas, i.e., wherein each base station transmits signals which propagate in a

substantially circular direction, i.e., 360 degrees. However, as will be appreciated by those skilled in the art, other antenna structures and transmission techniques may also be employed in radiocommunication systems. For example, a cell can be subdivided into several sectors, e.g., into three sectors where each sector covers a 120 degree angle as shown in Figure 2. Alternatively, the system or cell may employ an array antenna structure as shown in Figure 3. Therein, an exemplary radio communication system 200 includes a radio base station 220 employing a fixed-beam phased array (not shown). The phased array generates a plurality of fixed narrow beams (B_1, B_2, B_3, B_4, etc.) which radially extend from the base station 220, at least one of which (B_1) is used to communicate with MS 210. Preferably, the beams overlap to create a contiguous coverage area to service a radio communication cell. Although not shown, the phased array can actually consist of three phased array sector antennas.

Of course, the principles described above with respect to hard and soft handoff for omnidirectional antennas in Figures 1(a) and 1(b) can be directly mapped to other systems which employ sectorized and/or array antennas. In these latter types of systems, hard and soft handoffs can be performed between sectors or beams of the same base station as well as between sectors or beams associated with different base stations.

Both types of handoff have their drawbacks and advantages. On the one hand, soft handoff provides a robust mechanism for changing the connection from one base station to another. However, since the mobile station is connected to more than one base station during soft handoff, soft handoff requires more system resources than hard handoff. An advantage of hard handoff, therefore, is a reduced

need for system resources, while its drawback is a higher probability of dropped calls when compared to soft handoff.

Both hard and soft handoffs are employed in some radiocommunication systems. For example, Figure 4 illustrates a system described in WO 96/02117, wherein soft and hard handoff are applied sequentially. Therein, a system containing two base station controllers, BSC1 and BSC2, is shown. BSC1 controls base stations BTS11, BTS12 and BTS13, while BSC2 controls base stations BTS21, BTS22, and BTS23. The area that is served by all of the base stations coupled to a BSC is called a "BSC area".

Assume for this example, that the mobile station (MS) moves from cell A served by the base station BTS12 to cell B, which is at the border between two BSC areas. Cell B is served by two overlapping base stations, BTS11 and BTS21. BTS11 is coupled to controller BSC1, and BTS21 is coupled to base station controller BSC2. As the MS moves to cell B, it carries out a soft handoff controlled by BSC1 to a traffic channel of base station BTS11.

Assume further that the MS continues onward toward cell C and finally enters into its area of radiocommunication coverage. The base station BTS22, serving cell C, is under the control of BSC2. Before it is possible to activate the base station BTS22 for the handoff, the call control must first be switched to base station controller BSC2 from the previous controller BSC1. This is accomplished by performing a hard handoff. The MS performs a hard handoff from the base station BTS11 to the base station BTS21, and consequently, the base station controller change from BSC1 to BSC2 takes place. Finally, a soft handoff from BTS21 to BTS22 is performed.

However, these techniques described in WO 96/02117 do not provide a mechanism for controlling the use of either soft or hard handoff. Instead, these techniques are simply provided as an intended mechanism for reducing interference and signaling overhead associated with the handoff of a mobile area from a service area under the control of a first BSC to a service area under the control of a second BSC. Thus, these techniques do not provide any solution for controlling the usage of soft and hard handoff between cells *per se*.

According to European Patent Application 817 517 A1, as illustrated in Figure 5, a technique is presented for determining an appropriate type of handoff for a mobile station. In the Figure, the received perch channel (i.e., a type of broadcast control channel) level is shown for the cell where the MS resides initially (solid line) as well as for a neighboring cell (dashed line). The received levels are given with respect to the position of the mobile station.

According to EP 817 517 A1, the handoff type judgement method for a CDMA mobile communication system provides different types of handoff with different handoff start conditions. A type of handoff for which a handoff start condition is weakest, among the available types of handoff at a mobile station, is evaluated first. It is determined whether the handoff start condition for this type of handoff is satisfied or not at the mobile station. Each base station is notified for carrying out that type of handoff when the handoff start condition for that handoff is satisfied.

However, the techniques described in EP 817 517 A1 require that the mobile station be informed for each sector regarding which type of handoff is available. Hence out of a number of possible cells/sectors suitable for handoff with, possibly, different available handoff types, the mobile station first has to select all

cells/sectors that are available for the handoff type with weakest start condition. In a second step, a judgement among all of these cells/sectors will be performed. Thus, these techniques suffer from the drawbacks of having a two step procedure that requires intense signalling between the network (i.e., the base station) and the mobile station and that it is also quite complex to implement.

Accordingly, there is a need to develop enhanced techniques to determine when a handoff is appropriate, and which type of handoff is appropriate, to efficiently utilize system resources under different operating conditions.

SUMMARY

These, and other, problems, drawbacks, and limitations of conventional handoff techniques, are overcome according to the present invention in which a mechanism is provided for controlling the usage of soft and hard handoffs. According to exemplary embodiments of the present invention, methods and systems determine which handoff type is preferred at a specific location under current radio conditions. Another object of the present invention is to control hard and soft handoff while at the same time minimizing the overhead signalling between the network and the mobile station. Yet another object is to provide control methods and systems which are applicable to radiocommunication systems that use more than one frequency band to support communications in a cell/sector at the same time.

These, and other objects of the present invention are attained by a method for controlling handoff of a mobile station to a target transmission source in a radiocommunication system which comprises the steps of:

grouping a number of transmission sources into a group;

assigning, to an active set associated with said mobile station, at least one transmission source from said group;

selecting a first type of handoff to occur to at least one target transmission source if said at least one target transmission source is within said group; and

selecting a second type of handoff to occur to said at least one target transmission source if said first type of handoff is not selected.

In the method, a grouping of transmission sources (e.g., cells, sectors, base stations, beams or combinations thereof) is performed into groups which are denoted as softzones. Each softzone has its own softzone identity. Softzone identities can be reused for sectors which are not too close to each other. All members in the active set have the same softzone identity. However, each transmission source may belong to multiple softzones, i.e. it is possible that a transmission source is assigned to different groups.

Softzone handoff mechanisms according to the present invention provide a number of benefits. For example, the overhead signalling between the mobile station and the network associated with controlling handoff type selection will be reduced as compared, for example, to the techniques described in EP 817 517 A1. This is due to the fact that cells/sectors are grouped into different softzones instead of treating each cell/sector separately for the purpose of determining which type of handoff, if any, is appropriate. Moreover, these techniques provide a one-step procedure which permits great flexibility in the number of different handoff types that can be used.

Cell planners can use the softzone concepts described herein as a tool to take into account that between certain cells hard handoff might be more reasonable while

between other cells a soft handover might be most suitable. Moreover, the grouping of transmission sources into particular softzones need not be static, e.g., a network operator may adjust softzone assignments based on changes to system structure (e.g., cell addition or cell splitting), changing load conditions, etc. Softzones can also be automatically regrouped by way of a dynamic regrouping algorithm, e.g., based on current network resources, air interface resources and loading patterns.

In a preferable embodiment of the method said first type of handoff is a soft handoff. In a soft handoff, at least one transmission source of the active set and at least one target transmission source in the handoff transmit substantially the same information to a mobile station at substantially the same time. The second type of handoff is preferably a hard handoff wherein a mobile station ceases receiving transmissions from one transmission source prior to receiving transmissions from a target transmission source. In an exemplary embodiment, soft handoffs may only be performed with transmission sources having the same softzone id as current members of the active set. Likewise, hard handoffs may only be performed to transmission sources having a different softzone id than current members of the active set.

Examples of suitable transmission sources include a cell, a base station, a frequency band, a beam associated with an antenna array and a sector. Preferably, the membership of transmission sources to a group can be readjusted.

A base station operating in a radiocommunication system can support communication on two or more different frequency bands. In this case, a suitable

choice of the groups is that transmission sources in a first frequency band supported by said base station are assigned to one group.

The step of selecting a type of handoff preferably comprises the step of measuring a quality level associated with transmission sources a group. The measured quality levels can then be evaluated in conjunction with at least one threshold. The membership in the active set of the mobile station can in this way be based on a result of the evaluating step. A preferable threshold can be adjusted. It can vary, for example, as a function of a quality level associated with a member of said active set.

Preferable quantities for the measurement of the quality level are for example the downlink signal-to-interference ratio, downlink received signal strength, downlink pathloss or downlink pathloss plus uplink interference. Combinations of different quantities can be used.

Preferably, group identifiers of transmission sources are transmitted to the mobile station.

A controller for controlling handoff of a mobile station to a target transmission source in a radiocommunication system comprises, according to the invention, preferably a processor selecting a soft handoff of a connection from at least one first transmission source, having a first group identification assigned thereto, to at least one second transmission source, having a second group identification assigned thereto, when said first and second group identifications are the same. A transmission source can include for example one or more beams of an antenna array

or one or more sectors associated with one or more base stations. A hard handoff of said connection from one of the first transmission sources to one of the second transmission sources is selected when said first and second group identifications are different. It is possible that a transmission source is assigned to both said first and second groups.

In a preferable embodiment, the transmission sources comprise transceivers disposed within a same base station but which support communications on different frequency bands.

In a preferable embodiment, a processor in the controller can reassign a transmission source from a first group identification to another group identification. The processor can be identical to or different form the processor selecting the transmission device.

The controller can be disposed in a switch of the communication network. Switches are nodes in the network of the communication system for controlling connections like for example a BSC (base station controller) or an MSC (mobile switching center) according to GSM or UMTS specifications or an RNC (radio network controller). The controller can also be disposed in a mobile station.

A preferable radiocommunication system according to the invention comprises at least one first transmission source, having a first group identification assigned thereto and supporting a connection with a mobile station. A second transmission source has a second group identification assigned thereto. A processor associated

with a network controller, e.g. a switch, for controlling operations of the transmission sources and said mobile station selects a soft handoff of the connection from one of the first transmission sources to one of the second transmission sources when the group identifications are the same. When said first and second group identifications are different, a hard handoff of said connection from a first transmission source to a second transmission source is selected.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing, and other, objects, features and advantages of the present invention will be more readily understood upon reading the following detailed description in conjunction with the drawings in which:

Figure 1(a) is an illustration of hard handoff;

Figure 1(b) is an illustration of soft handoff;

Figure 2 depicts a base station employing sector antennas;

Figure 3 shows a base station employing an array antenna;

Figure 4 is an illustration of a conventional technique for performing sequential hard and soft handoffs to handoff a connection involving two base station controllers;

Figure 5 depicts another conventional technique for controlling different types of handoff;

Figure 6 is a block diagram showing various functional blocks of an exemplary mobile station;

Figure 7 is a graph illustrating various handoff algorithm conditions for adding, deleting and replacing sectors;

Figure 8 shows three cells grouped into two softzones used to describe exemplary embodiments of the present invention; and

Figure 9 is a graph of measured quality versus time used to explain handoff techniques according to exemplary embodiments of the present invention.

DETAILED DESCRIPTION

In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular circuits, circuit components, techniques, etc. in order to provide a thorough understanding of the invention. However it will be apparent to one skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well-known methods, devices, and circuits are omitted so as not to obscure the description of the present invention with unnecessary details. For example, although not described in detail herein, the present invention is applicable to radiocommunication systems which employ any type of access methodology, e.g., Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), or any hybrid thereof.

Moreover, this specification describes techniques that are applicable to different types of handoffs. However, these techniques can be applied to handoffs from or to any transmission source, e.g., a cell, a base station, a sector, a beam, a transceiver, etc. Accordingly, although the term "cell" is used primarily herein to illustrate how handoff mechanisms according to the present invention operate, it will

be appreciated by those skilled in the art that these techniques apply equally to any type of transmission source.

Prior to describing the details of the present invention, an example of the construction of a mobile station which can operate to perform the signal quality measurements described above is illustrated in Figure 6. This block diagram has been simplified to illustrate only those components relevant to the measurement of downlink signal strength, however those skilled in the art will be well aware of the other major functional blocks associated with mobile stations. In Figure 6, incoming radio signals are received by transmitter/receiver TRX 500. The timing is synchronized to the received symbol sequence by microprocessor controller 530. The strength of the received signals are measured by a signal strength measuring part 520, the value of which is then passed to microprocessor controller 530. The bit error rate (BER) of the received signal can also be determined as an indication of received signal quality as reflected by block 540. This measurement of received signal quality is particularly relevant in determining when an intracell handoff is desirable. Of course, the present invention is applicable to systems which use any type of quality measurement parameter, e.g., signal-to-interference ratio, received signal strength or pathloss. The mobile station will also have input/output devices, such as a keyboard and display 535, as well as a microphone and speaker unit (not shown), which enables information to be exchanged between the mobile station and the base station.

When the mobile station receives a list of channel numbers, codes or other channel identifying information in a measurement command, it will measure the received signal quality associated with each of those channels. Once the mobile station has made the requested measurements, at least two different evaluation

techniques can be employed. First, if network evaluated handoff (NEHO) is employed, then the mobile station will report the measurements to the system which will then evaluate the various sectors using a handoff algorithm. Alternatively, if mobile evaluated handover (MEHO) is employed, then the mobile station itself will evaluate the various sectors.

An example is provided in Figure 7 to illustrate how the active set may change over time based on applying a handoff algorithm to these measurements. Taking as a given that there are four sectors (A,B,C,D) of interest in the handoff scenario of Figure 7, it is initially assumed that only sector A belongs to the active set. The measurement set in this example contains all sectors of the active set and all the neighbors of the active set, in this example A, B and C. Generally speaking, the measurement set contains all of the transmission sources for which the mobile station makes measurements. The measurement set typically includes all members of the active set, as well as transmission sources which are neighbors of the transmission sources in the active set. The measurement set is also typically defined by the network and periodically transmitted to the mobile station.

This exemplary handoff algorithm dictates that different handoff actions will be triggered according to the conditions stated below:

1. Add a sector: A sector X is added to the current active set if its quality Q_x meets the following condition:

$Q_x > Q_{best}$ - add_th

where Q_{best} represents the quality of the sector with the best quality in the Active Set and add_th is a threshold value. For example, as shown in Figure 7, sector B is added to the active set at the time instant marked 'Add B' since the

difference between its quality level and the quality level received from sector A falls below add_th. Note that after time 'Add B', sector D is added to the measurement set because it is a neighbor to sector B.

2. Delete a sector: A sector X is deleted from the current active set if its quality Q_x meets the following condition:

$$Q_x < Q_{best} - \text{delete\_th}$$

where delete_th represents the deletion threshold. An example of this condition occurring may be found at time instant marked 'Remove C' in Figure 7, wherein sector C is removed from the active set since the difference between its received quality level and that of sector B exceeds delete_th.

3. Replace a sector: The maximum number of cells allowed in the active set is limited. Once this maximum number is reached , the active set is said to be full. A sector X replaces the sector with the worst quality in the active set if the active set is full and the following condition holds:

$$Q_x > Q_{worst} + \text{replace\_th}$$

where replace_th represents the threshold used for sector replacement. Provided that the maximum number of sectors in the active set is two in Figure 7, sector C should replace sector A at time instant marked 'Replace A with C' in Figure 7.

4. Perform a hard handover: A hard handover from the current active set to a new sector is carried out if the quality Q_x of sector X fulfills the following condition:

$$Q_x > Q_{best} + \text{hho\_th}$$

where hho_th represents the threshold used for hard handover, i.e., all connections of the current active set will be removed and a new connection to sector X will be set up. This is, for example, the case at the time instant marked 'hard handover to D' in Figure 7.

The actions described in this handoff algorithm to add, delete or replace a sector occur as soft handoffs in this example, unless the hard handoff threshold is exceeded in which case hard handoff takes precedence. However, according to exemplary embodiments of the present invention, additional control mechanisms are established to determine whether a soft or hard handoff is appropriate. More specifically, the present invention adopts an overlay mechanism referred to herein as a "softzone". The softzone is a group of cells, base stations or other transmission sources (e.g., sectors, beams, etc.) which can be identified by, for example, a softzone identification number (softzone id). Soft handoffs are then permitted only between members within the group having the same softzone id. The active set has a softzone identity which is referred to herein as the "active softzone identity". The softzone ids will be distributed from the network to the mobile station on either common or dedicated channels. Thus, the handoff rules described above with respect to Figure 7 are modified according to this exemplary embodiment such that:

1. When the quality of a measured cell (base station, transmission source, beam, sector, etc.) exceeds the value Q_{best} - add_th (the addition threshold), and the measured cell has a softzone identity which is identical to the active softzone identity, then the cell will be added to the active set in a soft handoff action. If the measured cell has a different softzone identity than the active set cells, the measured

cell will not be added to the active set, even though the quality of the measured cell exceeds Q_{best} - add_th.

2. When the quality of a measured cell (base station, transmission source, beam, sector, etc.) drops below the value of Q_{best} - delete_th (the deletion threshold), and the measured cell belongs to the current active set, then the cell will be deleted from the current active set as part of a soft handoff operation.

3. When the quality of a measured cell (base station, transmission source, beam, sector, etc.) exceeds the value of Q_{best} + hho_th (the hard handover threshold), and the measured cell does not have a softzone identity which is identical to the active softzone identity, then a hard handoff will be performed to the measured cell. If the measured cell has the same softzone identity as the active set cells, no handoff action will be taken.

4. When the quality of a measured cell (base station, transmission source, beam, sector, etc.) exceeds the value of Q_{worst} + rpl_th (the replacement threshold), and the measured cell has a softzone identity which is identical to the active softzone identity, then the measured cell will replace the active set cell with the worst quality.

Of course, the softzone identities must be known in the mobile station (in the case of MEHO) or in the network (in the case of NEHO). Thus, in the former case, the

softzone identities will be transmitted to the mobile station beforehand. The values of the various handoff thresholds described herein may be fixed or may be variable with respect to, for example, the quality level of the best cell (base station, transmission source, beam, sector, etc.) in the active set.

An illustrative example is provided in Figures 8 and 9 to further explain softzone handoff concepts according to exemplary embodiments of the present invention. In Figure 8, three cells (A, B and C) are depicted that belong to two different softzones SZ1 and SZ2 and, therefore have different softzone ids. Initially, for this example, assume that a mobile station (not shown in Figure 8) is only connected to cell A. When the quality of cell B satisfies the condition to add a cell, i.e., at time instant "add B" in Figure 9, a connection to cell B is added, since cells A and B both belong to softzone SZ1. Although the quality of cell C exceeds the addition threshold as well, i.e., at time instant "no SHO" in Figure 9, cell C is not added by way of soft handoff since cell C has a different softzone identity than the current members of the active set A and B.

After cell A has been deleted from the active set, i.e., at time instant "delete A" in Figure 9, the quality of cell C exceeds the hard handoff threshold. Thus a hard handoff will be performed that removes cell B from the active set and adds cell C thereto at time instant "hard handover to C" in Figure 9, since cell C belongs to softzone SZ2, while cell B belongs to softzone SZ1. Of course, if cells B and C had belonged to the same softzone, then no action would have been taken at time instant "hard handover to C" in Figure 9 because in this case cell c would have been added to the active set at time instant "no sho".

Softzone handoff mechanisms according to the present invention provide a number of benefits. For example, the overhead signalling between the mobile

station and the network associated with controlling handoff type selection will be reduced as compared, for example, to the techniques described in EP 817 517 A1. This is due to the fact that cells/sectors are grouped into different softzones instead of treating each cell/sector separately for the purpose of determining which type of handoff, if any, is appropriate. Moreover, these techniques provide a one-step procedure which permits great flexibility in the number of different handoff types that can be used.

Cell planners can use the softzone concepts described herein as a tool to take into account that between certain cells hard handoff might be more reasonable while between other cells a soft handover might be most suitable. In rural areas, for example, line of sight links between mobile stations and base stations are rather frequent. Typically, even in case of hard handoff, a reliable handoff will be performed. On the other hand, in urban areas, line of sight links are rather rare. Furthermore, connection quality may be poor due to shadowing effects. For these reasons, a call is likely to get dropped during a hard handoff, thus creating a preference for soft handoff under these circumstances. In such a scenario, one softzone identity could be assigned to several adjacent urban cells while several different softzone identities could be assigned to rural cells.

Moreover, the grouping of transmission sources into particular softzones need not be static, e.g., a network operator may adjust softzone assignments based on changes to system structure (e.g., cell addition or cell splitting), changing load conditions, etc. Softzones can also be automatically regrouped by way of a dynamic regrouping algorithm, e.g., based on current network resources, air interface resources and loading patterns.

Further, it is anticipated that system capacity will most likely be increased by implementation of the present invention, since the present invention offers the possibility to control soft and hard handoff whereby efficient use of system resources is promoted.

The above-described exemplary embodiments are intended to be illustrative in all respects, rather than restrictive, of the present invention. For example, although the preceding exemplary embodiments do not reference multiple frequency bands, it will be apparent to those skilled in the art that the present invention is applicable to systems employing multiple frequency bands for communication and, therefore, to either intrafrequency or interfrequency band handoff. Moreover, the same or different softzone ids may be provided for different frequency bands used by the same base station to provide communication services. Of course, for mobile stations having only a single receiver, i.e., which can only tune to a single frequency band at a given time, it would then be preferable to provide different softzone ids to different frequency bands employed by a particular base station, i.e., to force hard handoffs rather than soft handoffs therebetween.

Thus the present invention is capable of many variations in detailed implementation that can be derived from the description contained herein by a person skilled in the art. All such variations and modifications are considered to be within the scope and spirit of the present invention as defined by the following claims.

CLAIMS

1. A method for controlling handoff of a mobile station to a target transmission source in a radiocommunication system comprising the steps of:
grouping a number of transmission sources into a group;
assigning, to an active set associated with said mobile station, at least one transmission source from said group;
selecting a first type of handoff to occur to at least one target transmission source if said at least one target transmission source is within said group; and
selecting a second type of handoff to occur to said at least one target transmission source if said first type of handoff is not selected.

2. Method according to claim 1, wherein said first type of handoff is soft handoff wherein said at least one transmission source of said active set and said at least one target transmission source transmit substantially the same information to said mobile station at substantially the same time.

3. Method according to claim 1 or 2, wherein said second type of handoff is hard handoff wherein said mobile station ceases receiving transmissions from said at least one transmission source prior to receiving transmissions from said at least one target transmission source.

4. Method according to any preceding claim, wherein said transmission sources include at least one of: a cell, a base station, a frequency band, a beam associated with an antenna array and a sector.

5. Method according to any preceding claim, further comprising the step of adjusting membership of transmission sources of said group.

6. Method according to any preceding claim, wherein a base station operating in said radiocommunication system supports communication on at least two different frequency bands and wherein said step of grouping further comprises: grouping a first frequency band associated with said base station in said group.

7. Method according to any preceding claim, wherein said step of selecting a first type of handoff further comprises the steps of:
measuring a quality level associated with transmission sources in said group;
evaluating said measured quality levels in conjunction with at least one threshold; and
adjusting membership in said active set based on a result of said evaluating step.

8. Method according to claim 7, wherein said at least one threshold is variable.

9. Method according to claim 7 or 8, wherein said quality level is one of downlink signal-to-interference ratio, downlink received signal strength, downlink pathloss and downlink pathloss plus uplink interference.

10. Method according to claim 8 or 9, wherein said at least one threshold varies as a function of a quality level associated with a member of said active set.

11. Method according to any preceding claim further comprising the step of distributing group identifiers of transmission sources to said mobile station.

12. Method according to any preceding claim, wherein at least one transmission source is assigned to different groups.

13. A controller for controlling handoff of a mobile station to a target transmission source in a radiocommunication system with a processor for:
- selecting a soft handoff of a connection from at least one first transmission source, having a first group identification assigned thereto, to at least one second transmission source, having a second group identification assigned thereto, when said first and second group identifications are the same; and
- selecting a hard handoff of said connection from said at least one first transmission source to said at least one second transmission source when said first and second group identifications are different.

14. Controller according to claim 13, wherein said at least one first and said at least one second transmission sources are transceivers disposed within a same base station but which support communications on different frequency bands.

15. Controller according to any of the claims 13 or 14, wherein a processor can reassign said at least one first transmission source from said first group identification to another group identification.

16. Controller according to any of the claims 13 to 15, wherein the controller is disposed in a mobile station.

17. Controller according to any of the claims 13 to 15, wherein said controller is disposed in a switch.

18. A radiocommunication system comprising:
at least one first transmission source, having a first group identification assigned thereto and supporting a connection with a mobile station;
at least one second transmission source, having a second group identification assigned thereto;
a network controller for controlling operations of said at least one first and said at least one second transmission sources; and
a processor, associated with one of said network controller and said mobile station for:
- selecting a soft handoff of said connection from said at least one first transmission source to said at least one second transmission source when said first and second group identifications are the same; and
- selecting a hard handoff of said connection from said at least one first transmission source to said at least one second transmission source when said first and second group identifications are different.

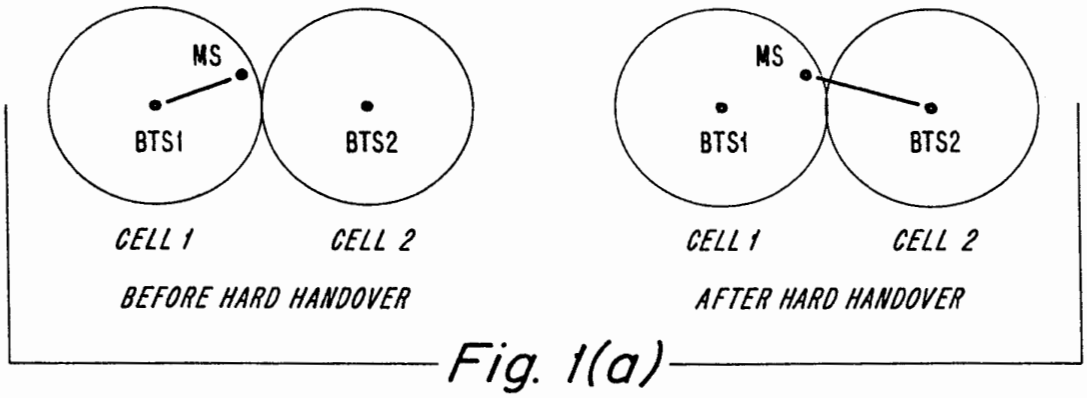
MS
BTS1
BTS2
CELL 1
CELL 2
BEFORE HARD HANDOVER
MS
BTS1
BTS2
CELL 1
CELL 2
AFTER HARD HANDOVER

Fig. 1(a)

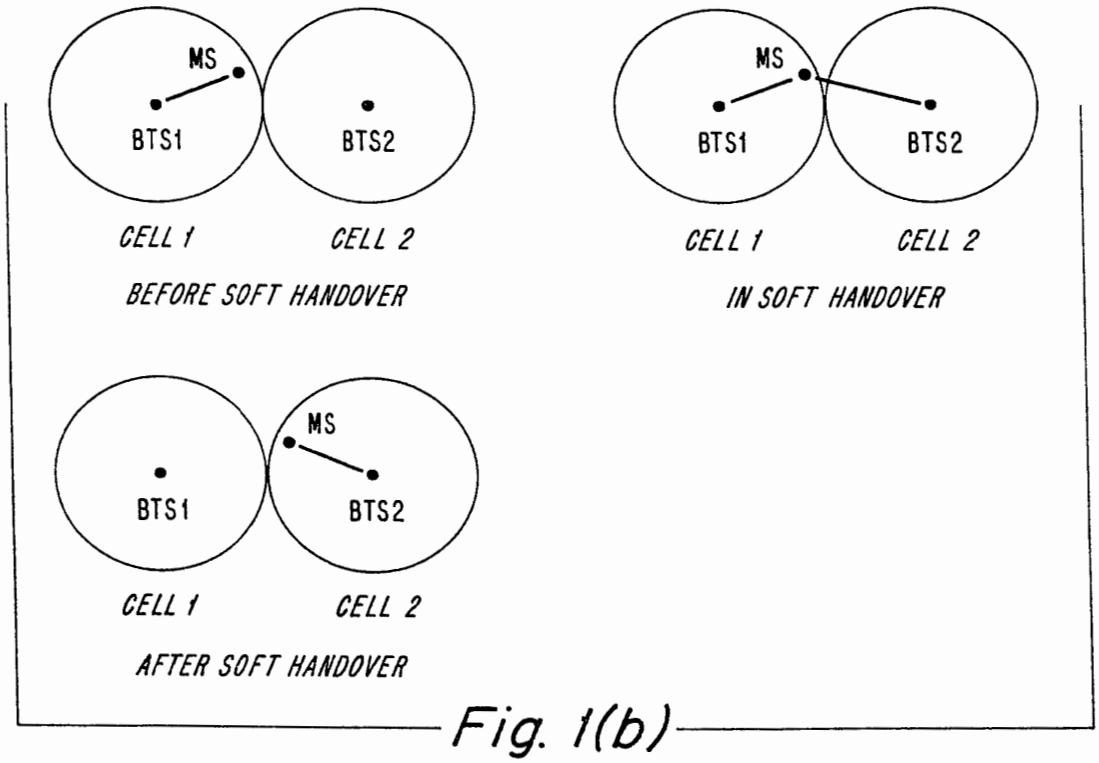
MS
BTS1
BTS2
CELL 1
CELL 2
BEFORE SOFT HANDOVER
MS
BTS1
BTS2
CELL 1
CELL 2
IN SOFT HANDOVER
MS
BTS1
BTS2
CELL 1
CELL 2
AFTER SOFT HANDOVER

Fig. 1(b)

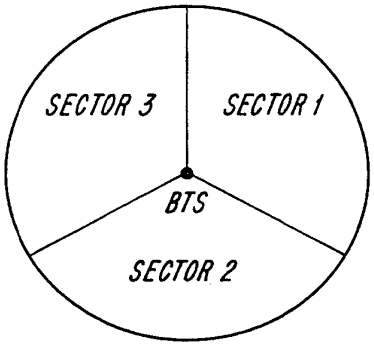

Fig. 2

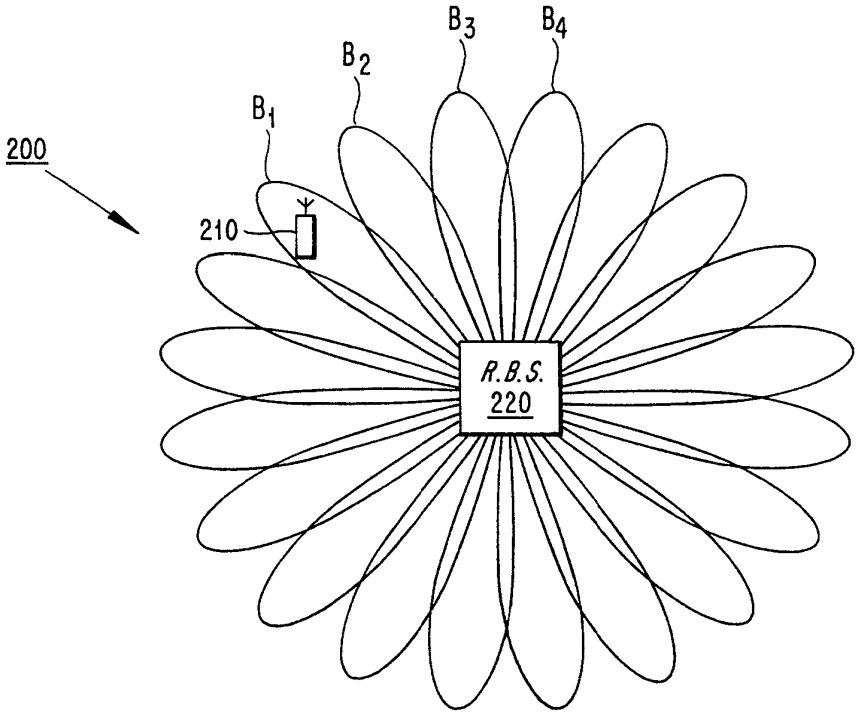

Fig. 3

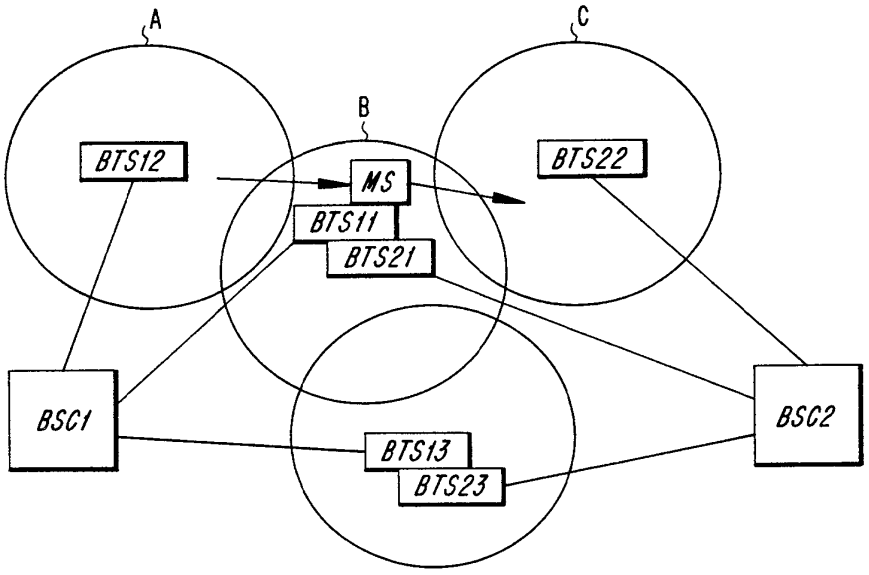

Fig. 4
(PRIOR ART)

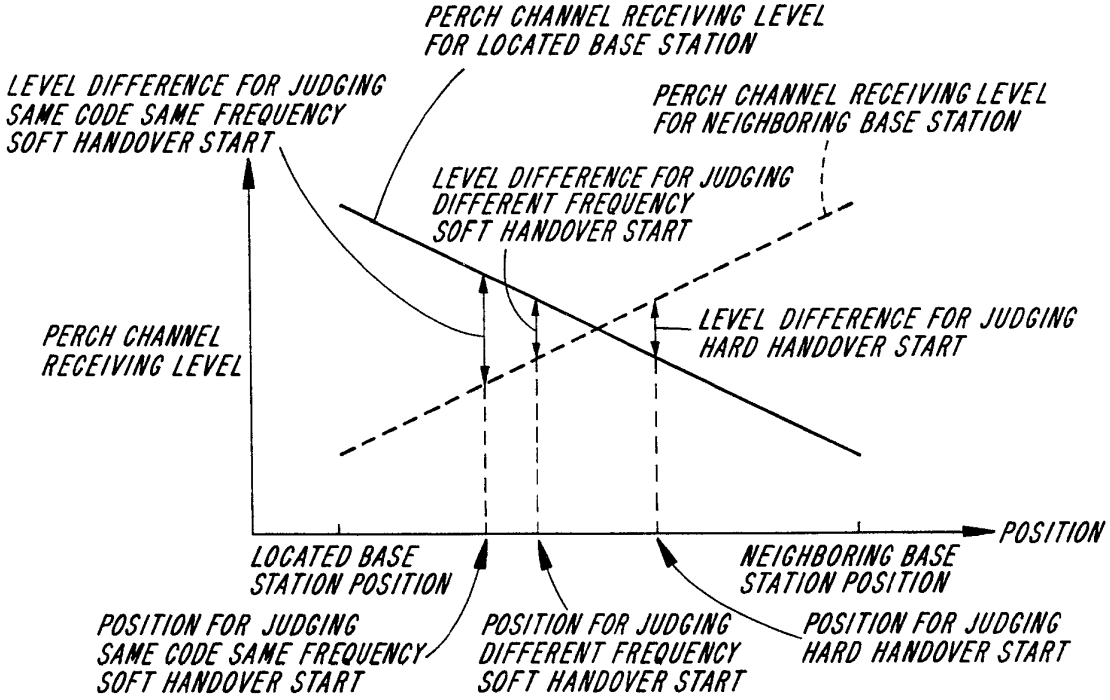

Fig. 5
(PRIOR ART)

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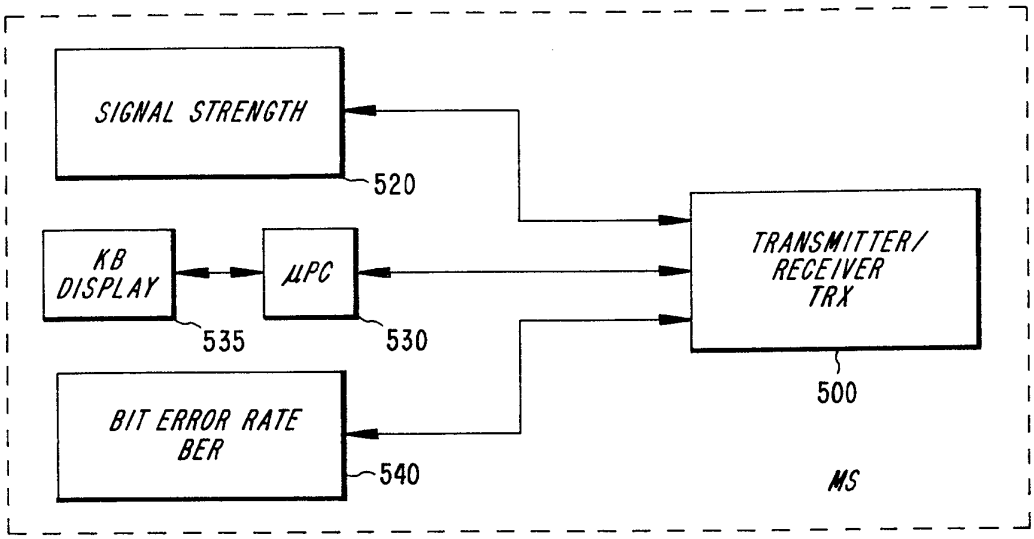
SIGNAL STRENGTH
520
KB DISPLAY
535
µPC
530
TRANSMITTER/ RECEIVER TRX
500
BIT ERROR RATE BER
540
MS

Fig. 6

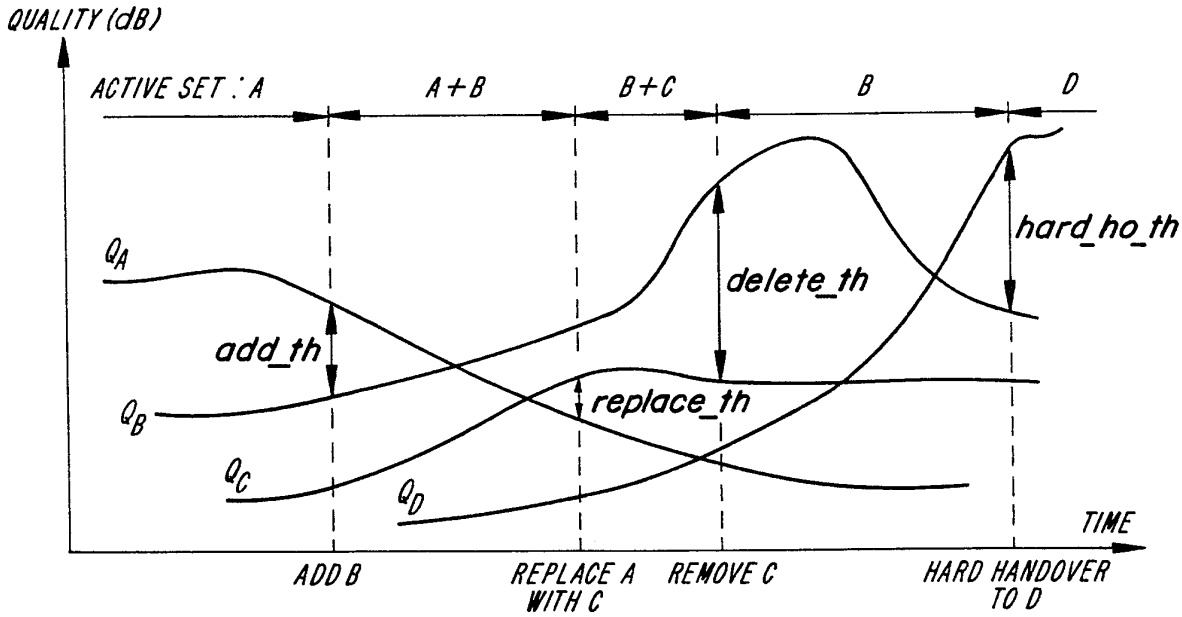
QUALITY (dB)
ACTIVE SET : A
A+B
B+C
B
D
Q_A
Q_B
Q_C
Q_D
add_th
delete_th
replace_th
hard_ho_th
TIME
ADD B
REPLACE A WITH C
REMOVE C
HARD HANDOVER TO D

Fig. 7

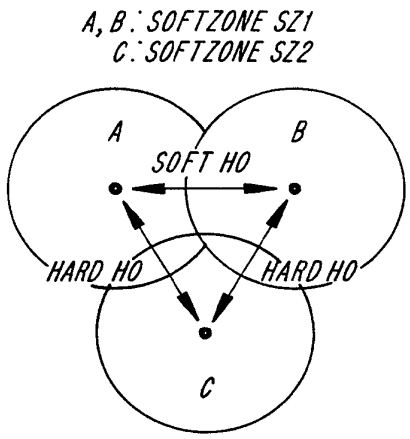

Fig. 8

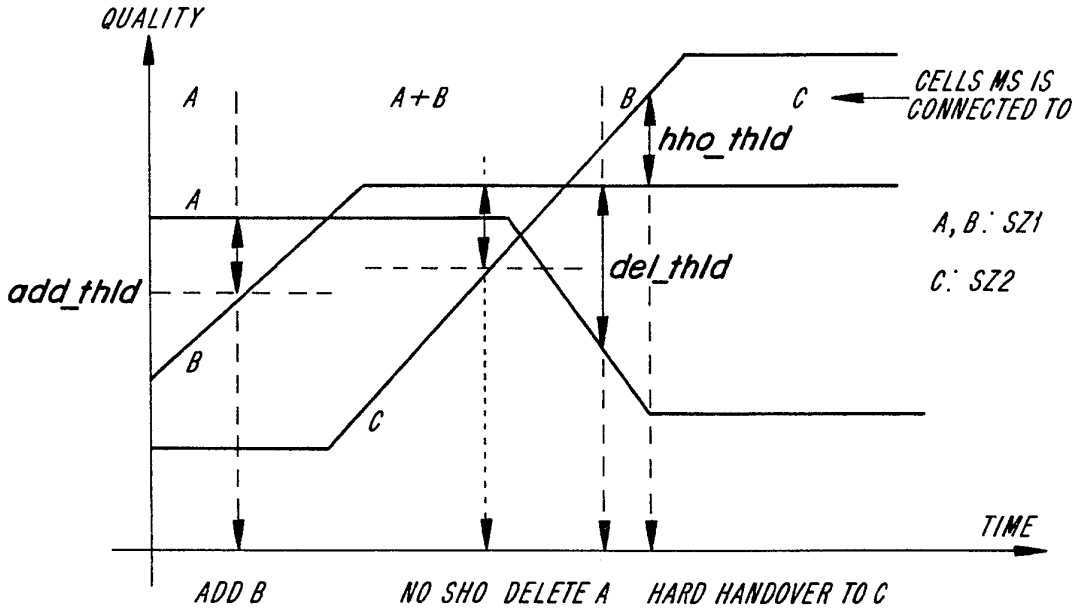

Fig. 9

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INTERNATIONAL SEARCH REPORT

Inte[illegible]onal Application No
PCT/EP 99/10083

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38

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)
IPC 7 H04Q

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 31078 A (QUALCOMM INC) 3 October 1996 (1996-10-03)	1-7, 9-11,13, 14,16-18
A	page 2, line 10 - line 17 page 6, line 32 - line 34 page 7, line 30 - line 37 page 9, line 29 - line 38 page 14, line 25 - line 33 -----	8,12,15

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"E" earlier document 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
26 May 2000	07/06/2000

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Janyszek, J-M

1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/EP 99/10083

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9631078 A	03-10-1996	US 5594718 A	14-01-1997
		AU 697734 B	15-10-1998
		AU 5432396 A	16-10-1996
		BR 9607948 A	14-07-1998
		CA 2216635 A	03-10-1996
		EP 0818117 A	14-01-1998

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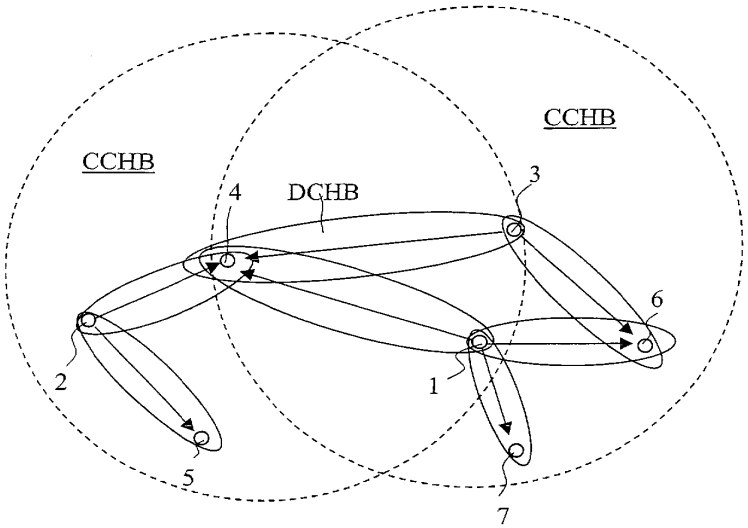
Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A DATA COMMUNICATION SYSTEM



(57) Abstract: A data communication system and a method for use in a data communication system is disclosed. The system comprises a plurality of nodes (1-7) provided with means for wireless data communication. At least one directed wireless communication link (DCHB) can be formed between a node and another node for data communication. In the method control information is generated, said information associating with at least one node of the plurality of nodes. Said control information includes at least a capacity parameter that associates with the capacity of said at least one node. Data communications between the nodes are scheduled based on said control information and data is communicated between the nodes via said at least one directed link based on said scheduling.

WO 02/063836 A2

A data communication system

Field of the Invention

The present invention relates to a data communications system, and in particular, but not exclusively, to a system comprising at least two nodes that are capable of communicating with each other over an air interface. The nodes may be data communication network elements such as routers or access points.

Background of the Invention

In a data communication system data may be transported between an originating i.e. transmitting node and a destination i.e. receiving node. A data transmission between the transmitting and receiving nodes may need to be transported via one or several intermediate nodes on the route between the transmitting and receiving nodes. In order to enable a transportation of the data to a correct destination address, a functionality referred to as routing is required. A node providing the routing function is referred to as a router. In the routing operation the data is typically routed i.e. directed either directly to the destination node or to another router node on the route towards the destination node.

Data communication systems enabling data transmission over an air i.e. wireless interface are known. An exemplifying wireless system is the so called wireless local area network (WLAN). The user terminals of a WLAN system are connected to access points of the WLAN via air interfaces. By means of this the WLAN provides mobility for the users thereof. However, the

price to capacity ratio of the present WLAN applications is not considered to be especially good.

In a wireless data communication system data can be transmitted over a wireless interface between two or more stations. The stations may be fixed or mobile stations. An example of the fixed station is a wireless router radio node. An example of the mobile station is a 3G mobile user equipment such as a third generation (3G) mobile telecommunications system mobile terminal. UMTS (Universal Mobile Telecommunication Service) is an example of the 3G standards.

The fixedly assembled components of a data network may also be in wireless communication with each other. For example, a router node may comprise a wireless IP (internet protocol) router, such as a wireless routing radio (WRR). A wireless router node may be based on use of time-division duplexing (TDD) together with time-division multiple access (TDMA).

In order to avoid a situation in which a wireless transmission causes interference to another transmission in the system and to ensure that the transmission can be received by the receiving station the transmissions need to be scheduled. The scheduling i.e. the order in which the neighbouring nodes may communicate on the radio channels can be based e.g. on the so called Neighbourhood Established Transmission Scheduling (NETS) scheme. The term 'neighbouring nodes' typically refers to those nodes in the neighbourhood of a node with which said one node can directly communicate with and with which said node has established neighbour relations. A node may choose that not all nodes that the node, at least in principle, could directly communicate with are its neighbours.

In the NETS scheme the nodes schedule their active radio links in the data channel such that various transmissions do not collide with each other and also such that the receiving station knows that it should receive data at a given moment of time in the future. For example, if a first node has reserved a time to transmit to a second node, the second node should prepare to receive at this time. Furthermore, all nodes that are located in the neighbourhoods of the first and second nodes should remain silent during the transmission in order to avoid interference.

In the conventional wireless data communication arrangements data is transmitted on a data channel by means of omnidirectional antenna arrangements. The omnidirectional transmission may cause substantial interference in all directions around the transmitting station. Thus it is especially important that all neighbouring stations remain silent during the transmission between the two stations.

Antenna arrays enabling directional transmission between two stations has been suggested in order to reduce the interference caused by omnidirectional antennae. Consequently a first node with a directional antenna should be allowed to transmit to a second node as long as the directional beam does not interfere with other active transmission links between other nodes. Directional beams can be used both for the reception and for the transmission.

A directional beam may be provided, for example, by means of so called 'switched beams or digital beam forming. The term 'smart antenna' is commonly use to refer to an antenna arrangement providing digital beam forming. However, the

inventor has found that the original NETS scheme does not optimally benefit from the use of directional beams.

The inventor has also found that it might be possible to increase the capacity of the wireless data communication system if the nodes could share at least a portion of the radio resources during the transmission and/or reception of data. That is, it could be advantageous if a node of the data communication system could communicate with at least two other nodes at the same time. It could be even more advantageous if the resources could be shared in both transmission and reception of data between the nodes.

Summary of the Invention

Embodiments of the present invention aim to address the problem related to the limited capacity of the prior art wireless data communication systems.

According to one aspect of the present invention, there is provided a method in a data communication system, said system comprising a plurality of nodes provided with means for wireless data communication, the method comprising: generating control information that associates with at least one node of the plurality of nodes, said control information including at least a capacity parameter associated with the capacity of said at least one node; scheduling data communications that associate with said at least one node at a given moment of time, said scheduling being based on said control information; forming a directed wireless data communication link between a node and another node; and communicating data between the nodes based on said scheduling.

According to another aspect of the present invention there is provided a data communication system comprising: a plurality of nodes, each of the nodes being provided with antenna means that are adapted to provide directed wireless data communication links with the others of the nodes; and means for communicating control information between the nodes, the control information including capacity information associated with at least one of the nodes, wherein the arrangement is such that data communications between the nodes over said directed communication links are scheduled based on said control information.

The embodiments may increase the capacity of a wireless data communication system. The capacity may be especially increased in embodiments where space division multiple access (SDMA) is used for the wireless data communication.

Brief Description of Drawings

For better understanding of the present invention, reference will now be made by way of example to the accompanying drawings in which:

Figure 1 shows a wireless data router system;

Figure 2 illustrates data communication between neighbouring nodes of a wireless data communication system;

Figure 3 shows a smart antenna arrangement;

Figure 4 is an example of the reservation of time slots for data communication in a frame; and

Figure 5 is a flowchart illustrating the operation of one embodiment of the present invention.

Description of Preferred Embodiments of the Invention

Reference is made to Figure 1 which shows a wireless data communication system comprising three wireless router nodes 1 to 3. The exemplifying router nodes are positioned on top of tall buildings 11 to 13 respectively. However, it shall be appreciated that manner how the router nodes are installed relative to the buildings is not an essential feature of the invention. A router node may be installed, for example, to the wall of a building, on the ground or on a specific construction designed solely for the purpose of supporting one or several router nodes. Each router node may comprise a wireless IP (internet protocol) router.

Each of the router nodes 1 to 3 is provided with transceiver means to enable wireless transmission and reception therebetween. The data transmissions at a given moment between the nodes 1 to 3 are indicated by the arrows between the nodes.

Although not shown for clarity reasons, a user terminal, such as a PC terminal or a mobile data processing device, may also have a wireless connection with a node providing an access point of the data network. The access point may be provided in one or all of the nodes 1 to 3 of Figure 1, or may be provided in a separate access node, such as a base transceiver station. A user terminal may also have a fixed connection to the routers. Furthermore, a user terminal may also provide a router.

Figure 2 is a schematic top view of a system that employs a plurality of wireless router nodes. The schematised wireless router node arrangement is shown to comprise seven nodes 1 to 7. The two circles drawn with dashed lines and designated by reference characters CCHB illustrate the substantially

omnidirectional control channel radiation patterns about nodes 3 and 4. It shall be appreciated that although all nodes may have substantially omnidirectional control channel radiation pattern or their own, only two control channel radiation patterns CCHB are shown for clarity reasons.

In accordance with the principles of the invention techniques the nodes are arranged to provide directional data communication between each other by means of directed data channel beams DCHB. The arrows between the nodes indicate the direction of data transmissions between the various neighbouring nodes occurring in a given moment of time.

It shall be appreciated that the Figure 2 illustration applies only for a given radio propagation environment. The number and shape of the radiation beams DCHB for the data transmissions that are directed towards the indented receiving neighbouring nodes will depend on the application and the environment.

More particularly, in a given moment of time (such as in a given single timeslot of a TDMA system) node 1 is shown to transmit to three different nodes 4, 6 and 7 at a same timeslot. Nodes 2 and 3 each transmit to two different nodes such that node 2 transmits to nodes 4 and 5 and node 3 transmits to nodes 4 and 6. Thus node 4 receives from three nodes, i.e. from nodes 1, 2 and 3. Node 6 receives from two nodes, i.e. from 1 and 3. Nodes 5 and 7 receive from one node only, i.e. from nodes 2 and 1, respectively.

At least some of the wireless router nodes 1 to 7 is provided with antenna means that are adapted to direct the transmission to a desired location. Alternatively, or additionally, at least some of the wireless router nodes 1 to 7 is provided

with antenna means that are adapted to direct the reception thereof towards a desired location. The directed transmission and/or reception may be provided by means of the directional transmission and reception beams. In a typical directive reception arrangement power received from a desired location is maximised.

A directional transmission or reception beam may be provided by a so called smart antenna arrangement. A smart antenna arrangement may provide a number of transmission and reception branches. A smart antenna system may be analogue or digital. The term smart antenna arrangement can typically, but not always, be understood to refer to an arrangement comprising the physical antennas, means to weight the transmissions and receptions corresponding to the different antennas and an algorithm or method to obtain proper antenna weights.

Figure 3 is a schematic illustration of a smart antenna arrangement 30 comprising four transmission branches. Each of the branches is preferably capable of serving the entire coverage area of the transceiver. A transmission branch may comprise an antenna element 15, a power amplifier 20 and digital or analogue circuitry 21 required to generate the signal to be transmitted by the antenna element 15. The antenna element 15 may be mounted on a mounting rack or similar mounting means 16.

An appropriate control equipment housing may also be provided. The housing may comprise a rack 18 for receiving the amplifier 20 and other circuitry 21 that may be required for the generation of the directed beam. The control instrument housing is preferably located such that it is readily accessible for maintenance and upgrade operations. In a

preferred embodiment the antenna elements 15 are located as high as possible while the housing is located on the ground or the roof or elsewhere such that an easy access for maintenance and/or upgrade purposes is enabled. The element 15 and the equipment in the housing are connected by means of appropriate cabling 19.

The beams i.e. radiation patterns produced by the array arrangement 30 can be shaped to have a narrower or broader radio coverage. Digital beamforming (DBF) can be advantageously employed in the provision of the directional beams. Advantages may be obtained since the digital beamforming enables tuning of the radiation pattern of an antenna array to have a desired shape. By mean of the desired shape the radiation pattern can be directed to point to a selected direction. In a typical digital beamforming implementation each branch is connected to an antenna element or antenna element polarisation port.

In the digital beamforming the transmission radiation pattern (beam) may be formed at the baseband by means of appropriate phasing and amplitude of the signal in each transmission branch. This may be accomplished by multiplying the complex digital samples in each transmission branch with a complex weight factor. The set of weight factors (one factor for each branch) is called the weight vector. A different weight vector may be used for transmission and reception. The digital beam forming enables provision of different number of transmission and reception beams.

In an analogue fixed beam implementation the beam may be formed e.g. by an analogue Butler matrix permanently connected to an antenna array. Thus when the same array is used for the

transmission and reception, the number of transmission and reception beams will be the same. For example, antenna means may provide eight directional reception and transmissions beams. In other words, in an analogue implementation a transmission branch produces a fixed transmission beam covering a geographical coverage area on which the transmitter may transmit to another station within the beam coverage area.

In both the analogue and digital implementations a greater number of branches typically provides a better capacity. The beams can be made narrower and thus the area served by a beam can be made smaller and pointed more precisely towards the counterpart in the communication.

The data transmissions between the nodes are preferably based on time-division multiple access (TDMA) together with space division multiple access (SDMA) technique and on time division duplexing (TDD). The relation between the TDMA and SDMA schemes is such that the TDMA defines the allocation of time slots for transmissions whereas the SDMA defines allocation of transmission resources within a time slot allocated based on the TDMA. In other words, SDMA enables division of a TDMA time slot so that data associated with more than one data transmission may be carried by means of said single time slot.

Both the transmitting and receiving stations are capable of operating in accordance with the SDMA scheme. The use of space division multiple access is advantageous since it can be used to increase the capacity of the data network. In the embodiments based on use of the SDMA advantages are especially obtained if control information that associates with smart-antennas of the nodes is shared between the router nodes of the system.

The control information may comprise several different parameters that may be used in the scheduling. The control information includes at least capacity parameter of a receiving node. If transmissions to more than one node are scheduled at the same time, the control information may include appropriate information by means of which it is possible to separate the nodes from each other.

The scheduling is distributed in the nodes. Each of the nodes may determine, e.g. based on a medium access control (MAC) address, when it is time to transmit on the control channel. That is, each node is allocated with a slot on the control channel.

In systems such as the space division multiple access (SDMA) the separation can be based on so called spatial signatures of the nodes, the spatial signatures describing the spatial characteristics of the respective radio channels between the neighbouring nodes. That is, nodes that are served in the same timeslot can be separated from each other based on their individual spatial signatures.

The spatial signatures of the neighbouring nodes are usually estimated based on training signals that have been sent by the nodes. Each node estimates the spatial signatures (with respect to itself) of all those other nodes that are located in its neighbourhood. The estimation may be based on continuous monitoring of the transmissions by the neighbouring nodes. Methods to obtain the SDMA weights for smart-antenna combining in transmission and reception are known and will thus not be explained in full detail. However, an example of a

possible method for the spatial signature determination will be given later.

In the embodiments of the present invention the maximum number of simultaneous communications (transmissions and receptions) a router node can handle is defined by a specific parameter. This parameter will be referred to in the following as capacity parameter and occasionally, where more appropriate, also as C_{SDMA}^{N} value. In C_{SDMA}^{N} the character 'N' labels the particular node.

The capacity parameter typically depends on the number of antenna elements that are used for forming the beams. In theory, N antenna elements can handle N-1 independent beams. In practice the capacity parameter may be smaller than N-1 depending e.g. on the radio propagation environment, interference and so on.

In the embodiments the capacity parameter is communicated to the neighbouring nodes. The communication occurs, for example, over a control channel between the nodes. However, it is not necessary to communicate the capacity parameter in each control-channel message since in a typical application the value of the capacity parameter is not likely to change very often.

The control channel transmissions are preferably arranged to be based on non-directional transmission and reception patterns. For example, as shown by Figure 2, the control channel radiation patterns CCHB may have substantially omnidirectional shape about the nodes. That is, all the nodes in the neighbourhood of a node should receive the control-channel information regardless the directional location of the

nodes. The data channel is made feasible for the operation of the smart-antenna arrangement providing directional beams, as described above.

The following describes how the control channel information may be employed in the SDMA data transmission scheduling. It is assumed in the following that each node is provided with information regarding the values of the capacity parameters of its neighbours. The following description assumes also that node 1 is provided with a timeslot on the control channel of the current frame. In this timeslot the node 1 specifies those nodes to which it will transmit data on the current frame and/or from which it will receive data on the current frame. The node 1 may also specify this for at least some of the future frames. These reservations will be referred to in this specification as active links.

The following will describe also several other parameters that can be included in the control information, such as parameters associated with transmit and receive directivities. However, information that is not likely to change, such as the transmit and receive directivities, or changes only rarely, is preferably not included in every control channel transmission.

The start times and duration of the active links may also be specified in the reservations. Node 1 may base the decisions regarding the timeslots for its active links on information it has received from the other nodes about their forthcoming transmissions during the earlier control channel timeslots to avoid collisions. In order to enable the scheduling operations the nodes are adapted to interpret the received control channel information to decide in which time slots they can

perform their transmissions and in which time slots they should be prepared to receive.

As explained above, e.g. in the conventional Neighbourhood Established Transmission Scheduling (NETS) scheme the nodes try to schedule their active links such that none of the transmissions collides with another transmission. For example, if the node 1 has reserved a time to transmit to node 2 in accordance with the NETS, all the nodes in the neighbourhoods of nodes 1 and 2 shall remain silent during this transmission in order not to cause interference.

The embodiments enable use of a scheduling scheme that is not as rigid as e.g. the conventional NETS. In this context the SDMA is advantageous since it enables simultaneous transmission and/or reception to and/or from several different nodes. The transmission and/or reception may occur simultaneously in common timeslots.

A simultaneous communication with several nodes may be accomplished if a node is capable of handling more than one reception simultaneously, that is if $C_{SDMA}^{N} > 1$ and if the node can separate the data in the incoming signals. Generally, a node is allowed to schedule a transmission to another node at time T if the number of already scheduled simultaneous transmission to said other node during that time is less than the C_{SDMA}^{N} value of said other node.

The use of the directional beams and the SDMA based allocation of the transmission resources enables the scheduling rule for the neighbouring nodes to be such that it is not necessary for the neighbouring nodes to be silent. The directional beams may be implemented, for example, by the above discussed switched

beams or digital beam forming. In addition, this also makes it possible to transmit to such nodes that are also in communication with other nodes.

Figure 2 exemplifies a situation in which a number of transmissions and receptions occur simultaneously in a wireless IP network that utilises an access technique such as the SDMA. As mentioned above, the SDMA enables the neighbours to transmit also to nodes that are in the process of transmitting to and/or receiving from other nodes.

The principle of the scheduling within a time slot is illustrated by Figure 4. Nodes 1, 2 and 3 are shown to transmit to a plurality of nodes during slot t1. Nodes 5, 6 and 7 are shown to receive from nodes 1 to 3. For example, node 3 is enabled to transmit to nodes 4 and 6 at the same time as node 1 transmits to nodes 4, 6 and 7. Correspondingly, nodes 4 and 6 should receive data from more than one node during this slot t1. For example, node 6 may receive from nodes 1 and 3 at the same time.

The simultaneous active links for communication can be specified by appropriate messages transported on the control channel of the frame, as shown by Figure 4. The indication mechanism may be similar to the indication of the conventional active links that are intended for different timeslots.

A node that is about to receive from several other nodes simultaneously can separate the received data e.g. based on the above discussed smart antenna weights. Thus e.g. node 6 determines proper smart antenna weights for all transmitting nodes to be able to digitally separate the different incoming

signals. These weights can be based on the spatial-signature estimates. It is possible to set also other relevant parameters for this purpose, such as expected values for timing and frequency errors.

Nodes that have a high C_{SDMA}^{N} value generally use antenna arrays provided with a substantially high number of antenna elements. Transmissions by such nodes can be made highly directional. The substantially narrow beams are not likely to cause significant interference to other simultaneous active links.

On the other hand, nodes with substantially small C_{SDMA}^{N} value transmit with a low directivity. In particular, nodes with C_{SDMA}^{N} = 1 transmit and receive omnidirectionally unless they use a switched-beams approach or digital beam forming without SDMA. This may be referred to as a single-user smart-antenna operation. Such nodes may cause a substantially strong interference to other simultaneous active links. In order to optimise the operation of the system it may thus be advantageous to reserve simultaneous active links in a common neighbourhood in the same timeslot with those active links that have a substantially high C_{SDMA}^{N} in the transmitting side.

It is also possible that the system includes nodes for which the C_{SDMA}^{N} = 1. Of these nodes the ones with omnidirectional antennas are substantially different from the interference point of view from those nodes that use directional transmissions but do not support SDMA.

Thus it may be advantageous in certain situations to include a measure indicative of the transmission directivity of a node

to the list of parameters to be communicated to the neighbours in order to optimise further the scheduling of simultaneous communications. Even if the SDMA is not employed, and when the C_{SDMA}^{N} = 1 for all the nodes, capacity can be enhanced through information regarding the transmit and receive directivity since this enables simultaneous active links for neighbouring nodes and enables relaxing the requirements of the basic NETS scheme.

Furthermore, for a single-user smart-antenna operation as well as for the SDMA the nodes can use zeroing (nulling) to further reduce unwanted interference (see the mathematical discussion regarding the interference below). Moreover, to optimise the zeroing performance, the lengths of the simultaneous transmissions in different active links in a common neighbourhood should preferably be as close to each other as possible. Otherwise a varying interference situation may occur during a single data packet – a situation which might not be as easily zeroed as the case with equal transmission lengths.

A measure that is indicative of the reception directivity of the receiving nodes can be of importance to the transmitting node also since the transmitting node may use this information in the scheduling operations to ensure that the transmissions thereof do not cause interference to reception of another active link.

The value of the capacity parameter may change e.g. based on changes in the capacity or in the quality of the radio connection. That is, a node may be upgraded or downgraded to handle more or less simultaneous communications. Furthermore, in situations where the load of the network is substantially high such that it is very unlikely that the node receives from

only one other node at a time and if there is only one choice for the training sequence, it may be advantageous if a node is able to temporarily set its capacity parameter value to unity in order to update the spatial-signature estimates for its neighbours. The current value of the capacity parameter may, for example, be included in the control-channel transmissions of each node or in some other control messages that are sent more seldomly.

According to a possibility a set of mutually orthogonal training signals is specified in the system. The transmissions to a node may then be scheduled such that transmissions from different nodes use different training signals. To achieve this information about the training signal that are used can be included in the control channel scheduling messages. Thus, after node 1, for example, has reserved timing for a node 1 to node 6 transmission, any node also wishing to transmit to node 6 at the same time may select a different training signal.

Based on different mutually orthogonal training signals for the different incoming transmissions the receiving node may estimate the spatial signatures during the SDMA operation. Thus it is possible to relax the requirement regarding the speed on which the radio channel may vary in the SDMA reception. Furthermore, to update channel estimates a node may not need to be set the value of the capacity parameter to unity.

The following will describe an exemplifying spatial signature determination procedure that relates to a wireless data communication system employing orthogonal frequency division multiplexing (OFDM) scheme. It shall be understood that the following is only an example, and other methods for the

estimation may also be used. In the OFDM the training sequence may consist of two identical consecutive OFDM symbols (training symbols) in which each of the subcarriers contain data that is known to the receiver .

The number of subcarriers depends on the particular communication standard. The following assumes that 52 subcarriers are employed. The system may apply e.g. 64 subcarrier frequencies, but of these only 52 subcarriers are used for data transmission. Of these 52 subcarriers, in turn, four are used as pilot carriers in all OFDM symbols. All the subcarriers used in the training symbols represent predefined data. Thus, the radio frequency radio channel *(H)* between the terminal and an element *n* of the array of antennas for a sub-carrier *k* can be estimated by equation:

$$H_n[k] = \left(\frac{1}{2} \sum_{p=1}^{2} x_n[k,p] \right) \times d[k]^*, \qquad (1)$$

in which $x_n[k,p]$ is a signal received from the antenna element *n* in the frequency domain at a subcarrier frequency *k=0,1,…,51* representing the pth training symbol in a training sequence transmitted by the terminal, $d[k]$ is the training symbol for the subcarrier *k*, and the character * as superscript indicates complex conjugation.

Because the effect of the radio channel is generally shown in time domain as a convolution with the transmitted signal, this corresponds, at each subcarrier frequency in the frequency domain, to complex multiplication of the transmitted symbol and the radio channel. It is now possible to determine a weight vector, whose complex conjugate is used in the

receiving station to weight signals received from the transmitting station by different antenna elements or signals to be transmitted from different antenna elements, for example depending on the frequency in the following way:

$$\overline{w}[k] = (H_0[k], H_1[k], H_2[k], \ldots, H_{N-1}[k])^T \qquad (2)\ [AA1]$$

In (2) superscript T indicates transposition and N is the number of the antenna elements.

The weighting coefficient vector (2) can be referred to as a spatial signature. The weighting coefficient vector (2) can be used both for reception (uplink) and transmission (downlink).

The access point i.e. the router node may apply the space division multiple access (SDMA) for simultaneous transmission to e.g. M different router nodes. In order to enable this the spatial signatures of the different nodes may be generally modified, that is, the weighting coefficients $\overline{w}_m[k]$ of the weighting coefficient vector may be modified to the form $\overline{w}'_m[k]$ so that when a signal intended for a node $m = 1, 2, \ldots, M$ is weighted by the weighting coefficients $\overline{w}'_m[k]$, the power received by the node m is as high as possible and at the same time the power received by other nodes to be simultaneously served from the transmission in question is as low as possible. Thus, for example, it can be required that:

$$\overline{w}'^{H}_a[k] \cdot \overline{w}_b[k] = \delta_{a,b} \quad \forall k, \qquad (3)$$

in which $\delta_{a,b}$ is a Kronecker delta (1 if a=b and zero otherwise) and $\forall k$ indicates that the condition is valid for

each subcarrier frequency separately. This condition can be fulfilled for example by using the pseudo inverse:

$$A_{sdma}[k] = \left(A[k]^{+}\right)^{H}, \qquad (4)$$

in which the superscript + indicates pseudo inverse and $N \times M$ matrices $A[k]$ and $A_{sdma}[k]$ are defined:

$$A[k] = (\overline{w}_1[k], \overline{w}_2[k], \ldots \overline{w}_M[k]) \qquad (5)$$

and

$$A_{sdma}[k] = (\overline{w}_1'[k], \overline{w}_2'[k], \ldots \overline{w}_M'[k]) \qquad (6)$$

A corresponding modification can be accomplished in the receiving node. When a received signal is combined with the weighting coefficients $\overline{w}_a'[k]$, the signal transmitted by the transmitting node 'a' is amplified as much as possible, whereas the signals transmitted simultaneously by other nodes are attenuated as much as possible. In other words, the signal transmitted by the transmitting node is summed from the different antenna elements as coherently as possible when weighted with the weighting coefficients $\overline{w}_a'[k]$, whereas the signals of other nodes transmitting simultaneously are summed as incoherently as possible.

In most occasions it can be assumed that the weight vector and spatial signature mean essentially the same factor. For example, in Figure 1 node 1 is provided with an estimate of the direction in which node 2 is located. The weight vector that shall be used to form a transmission beam towards this direction corresponds to the spatial signature of node 2 as seen by node 1. That is, the spatial signature of node 2

depends on the position of node 2 relative to node 1. The weight vector for the forming of the beam from node 1 towards node 2 depends of the spatial signature of node 2 as seen by node 1.

The spatial signature is defined for a link between two nodes. If node 1 transmits to two nodes 2 and 3 at the same time it is possible for node 1 not to use the original weigh factors of nodes 2 and 3. Instead, node 1 may modify the weight factor vectors so that the other one of the two nodes is always zeroed. That is accomplished in order to prevent the transmission that was intended to node 2 to enter node 3 and vice versa (see the discussion above).

If the two nodes have a line of sight (LoS) between them, the direction and location of the receiving station can be considered to be the same. LoS is a typical condition when the router nodes are installed outdoors, such as in Figure 1. However, if the nodes do not have a visible contact with each other a substantial portion of the radio propagation may be subject to reflections. The reflected signals may arrive from various directions. Thus in certain circumstances it is more correct to understand the operation of a smart antenna system such that it directs the transmission and/or reception to a desired location, not just to a desired direction.

The TDD based systems are advantageous in this sense since the uplink and the downlink use the same frequency. In the TDD based systems it is not necessary to consider the directed transmissions in the terms of directions of the beams but, instead, the operation can be seen as a formation of a region of constructive interference around a node. For example, an

interference maximum can be located to be present around the location of a receiving node.

The spatial-signature estimates may need an update from time to time, depending on the application. The more slowly varying the radio environment is, the more seldom an update of the spatial-signature estimates is needed and vice versa.

Despite the possibility to update the value of the capacity parameter it may, however, be advantageous in some applications if the radio environment of a node does not vary too rapidly. Too rapid variations in the radio channel conditions may prevent use a spatial-signature estimate for a substantially long enough period of time, e.g. the use of a single spatial-signature measurement for several frames. This may be of especial importance if the system uses only one type of training sequence. This may be the case, for example, for HIPERLAN/2 WLAN as well as for the WRR.

On the other hand, the requirement for slowly-varying radio environment can be relaxed for SDMA reception if a set of mutually orthogonal training signals is specified in the system. More particularly, even if the radio environment varies substantially rapidly the SDMA may still be made feasible in the reception if the system defines a set of mutually orthogonal training signals.

In extreme conditions (e.g. a fast moving node) an estimate of the channel may be needed for every packet in systems that require use of antenna weights for the communication by means of directional radiation patterns. Consequently, the total number of possible simultaneous active links in the neighbourhood of an active link between a first and a second

node would be limited by the number of different training signals (C_{TR}) that may be used. Thus in such circumstances the number of simultaneous active links to the second node may become limited by the C_{TR} value in addition to the limitation set by the capacity parameter. However, it shall be appreciated that this is not the case in all applications. For example, if fixedly mounted routers (see Figure 1) are used the radio channel is expected to remain the same over long enough periods of time.

It is also possible to estimate the interference content of the received signal. This may be done for example by forming a so called remainder signal

$$r_n[k,p] = x_n[k,p] - H_n[k] \times d[k] \qquad (7)$$

for the training symbols ($p = 1, 2$) that have been transmitted in an orthogonal system. To eliminate interference in the reception, the weighting coefficient vector can now be modified for example by multiplying it with the inverse matrix of the position correlation matrix of the remainder signal:

$$\overline{w}_{opt}[k] = \left(Q[k,p] + \gamma \times I\right)^{-1} \times \overline{w}[k], \qquad (8)$$

in which $Q[k,p]$ is the position correlation matrix of the remainder signal:

$$Q[k,p] = \overline{r}[k,p] \times \overline{r}[k,p]^H, \qquad (9)$$

$$\overline{r}[k,p] = \left(r_0[k,p], r_1[k,p], r_2[k,p], \ldots r_{N-1}[k,p]\right)^T, \qquad (10)$$

the superscript H indicates complex conjugate transposition, I is $N \times N$ unit matrix and γ is a small constant (for example, $\gamma = 0.01$) which makes the inverse matrix operation well-behaved in the equation (8). In equations (7) - (10) it is possible, for example, to restrict to use only one of the received training symbols, that is, for example to set $p = 1$ in equations (7) and (8). Alternatively, the inverse matrix for the equation (8) can be calculated for each training symbol separately ($p = 1$ and $p = 2$) and to take the average of these inverse matrices. Good simulation results have also been obtained by averaging the position correlation matrix over the frequency, by calculating the inverse matrix as in equation (7), and finally by taking the average over the training symbols:

$$\overline{w}_{opt}[k] = \left\{ \frac{1}{P} \sum_{p=1}^{P} \left[\left(\frac{1}{K} \sum_{k=0}^{K-1} Q[k,p] \right) + \gamma \times I \right]^{-1} \right\} \times \overline{w}[k], \qquad (11)$$

in which thus $P = 2$ and $K = 52$ for the HIPERLAN/2 system.

It is also possible that at least one of the transmitting or receiving stations comprises a mobile user terminal. The mobile terminal comprises a mobile station enabled to communicate with another station. At least a part of the nodes of the data communication system may be arranged to provide an access point (AP) for the mobile terminal (MT). The access point may comprise appropriate transceiver and controller means such as those known from the base stations for the cellular telecommunication systems.

The mobile terminals and access points may be arranged such that the mobile terminals have omnidirectional antennae (one

for each MT) while the access points may use array antennas as discussed above, measure the spatial signatures of different mobile terminals and utilise the SDMA. Those nodes of the system which do not provide the access point feature may be similar to the router nodes described above. The router nodes may be provided with antenna arrays and utilise spatial signatures of the other nodes. The router nodes may be capable of communication with the other router nodes and also with those nodes that provide the access points. Each of the routers may also transmit to and/or receive from the mobile terminal in the manner similar to reception and/or transmission between the router nodes of the system.

It shall be appreciated that although the above example mainly considers use of a TDD/SDMA system, other duplexing and access techniques may also be used where appropriate. Thus this invention is also applicable to any other access techniques including code division multiple access (CDMA), frequency division multiple access (FDMA) as well as any hybrids thereof. Any multiplexing scheme where time or frequency slots or similar are allocated for the data to be transmitted may also be used.

It shall also be appreciated that whilst embodiments of the present invention have been described in relation to wireless routers, embodiments of the present invention are applicable to any other suitable type of nodes. Consequently the embodiments can be applied to other network elements where applicable.

The data is described as being in packet form. In alternative embodiments of the invention the data may be sent in any suitable format.

Advantage may also be obtained in gateway nodes that connect the wireless network to other networks. This is so because the gateway nodes typically form bottlenecks through which the traffic between a wireless mesh network (typically more local) and a wired network (typically more global) is directed. The gateway nodes are sometimes referred to as sinks.

It is also noted herein that while the above describes exemplifying embodiments of the invention, there are several variations and modifications which may be made to the disclosed solution without departing from the scope of the present invention as defined in the appended claims.

Claims

1. A method in a data communication system, said system comprising a plurality of nodes provided with means for wireless data communication, the method comprising:

generating control information that associates with at least one node of the plurality of nodes, said control information including at least a capacity parameter associated with the capacity of said at least one node;

scheduling data communications that associate with said at least one node at a given moment of time, said scheduling being based on said control information;

forming a directed wireless data communication link between a node and another node; and

communicating data between the nodes based on said scheduling.

2. A method as claimed in claim 1, wherein the directed wireless data communication link is formed by means of at least one directional radiation pattern.

3. A method as claimed in claim 2, wherein said at least one directional radiation pattern is formed by a smart antenna arrangement.

4. A method as claimed in any preceding claim, wherein the directed wireless data communication link is formed by means of digital beamforming.

5. A method as claimed in any preceding claim, comprising a step of estimating information associated with the location of said at least one node.

6. A method as claimed in any preceding claim, wherein each of the nodes of the system is allocated with a time slot on a control channel for the provision of control information to the others of the nodes.

7. A method as claimed in any preceding claim, wherein those nodes of the system that are served in a time slot are separated from each other based on information that associates with the spatial characteristics of neighbouring nodes.

8. A method as claimed in claim 7, wherein the information regarding the spatial characteristics of the neighbouring nodes is determined based on training signals.

9. A method as claimed in any preceding claim, wherein data transmissions between the nodes of the system are based on space division multiple access (SDMA) technique.

10. A method as claimed in claim 9, wherein the space division multiple access (SDMA) technique is used in combination with time division multiple access (TDMA) technique.

11. A method as claimed in any of claims 7 to 10, wherein information associated with the spatial characteristics is provided by means of spatial signatures.

12. A method as claimed in any preceding claim, wherein the nodes of the system reserve data communication resources by generating control information and transmitting said control information to other nodes.

13. A method as claimed in any preceding claim, wherein the control information includes information that identifies those nodes to which a node intends to transmit data.

14. A method as claimed in any preceding claim, wherein the control information includes information that identifies those nodes from which a node expects to receive data.

15. A method as claimed in claim 13 or 14, wherein only those nodes are identified with which a node is going to communicate during a data transmission entity.

16. A method as claimed in claim 15, wherein the data transmission entity comprises a time slot, and a node reserves communication resources by providing an indication of those nodes the said reserving node is going to be in communication with during said time slot.

17. A method as claimed in any preceding claim, wherein the control information includes start times and duration of communication links a node is indenting to have with at least one of the nodes.

18. A method as claimed in any preceding claim, wherein the control information includes an indication of transmission and/or reception directivity of a node.

19. A method as claimed in any preceding claim, wherein the control information includes information that is associated with training signals to be used for the data communication between the nodes.

20. A method as claimed in any preceding claim, wherein the capacity parameter for a node defines the number of simultaneous active data communication links the node may have with other nodes.

21. A method as claimed in any preceding claim, comprising a step of updating the capacity parameter.

22. A method as claimed in any preceding claim, wherein the wireless data communication link is formed by means of a transmission beam that is directed to a certain direction.

23. A method as claimed in any of claims 1 to 21, wherein the wireless data communication link is formed by means of a transmission beam that is directed to a certain location.

24. A method as claimed in any preceding claim, wherein time division duplexing (TDD) is used for the communication between the nodes.

25. A method as claimed in any preceding claim, wherein the directed data communication link is formed by arranging multiple transmitted or received signals to constructively interfere at a desired location.

26. A method as claimed in any preceding claim, wherein non-directional communication links are used for communication of said control information between the nodes.

27. A method as claimed in any preceding claim, wherein the nodes transmit said control information on a control channel.

28. A method as claimed in any preceding claim, wherein a node is in simultaneous communication with a plurality of nodes during a common timeslot.

29. A method as claimed in any preceding claim, wherein a node is allowed to schedule a transmission to another node at time T if the number of already scheduled simultaneous transmission to said other node during that time is less than the value of the capacity parameter of said other node.

30. A method as claimed in any preceding claim, wherein at least one of nodes comprises a fixedly mounted router node for a data communication network.

31. A method as claimed in any preceding claim, wherein the data communication systems employs internet protocol for data communication.

32. A data communication system comprising:

a plurality of nodes, each of the nodes being provided with antenna means that are adapted to provide directed wireless data communication links with the others of the nodes; and

means for communicating control information between the nodes, the control information including capacity information associated with at least one of the nodes, wherein the arrangement is such that data communications between the nodes over said directed communication links are scheduled based on said control information.

33. A data communication system as claimed in claim 32, wherein the directed wireless data communication link is formed by means of at least one directional radio beam.

34. A data communication system as claimed in claim 33, wherein the antenna means comprise a smart antenna arrangement.

35. A data communication system as claimed in any of claims 32 to 34, wherein the antenna means comprise means for digital beamforming.

36. A data communication system as claimed in any of claims 32 to 35, wherein the control information includes also information associated with at least one of the following features or characteristics of the communication system: spatial characteristics of neighbouring nodes; indication of those nodes with which a node intends to communicate data; start times and duration of communication links a node is indenting to have with at least one other node; transmission and/or reception directivity of a node; training signals to be used for the data communication between at least two nodes.

37. A data communication system as claimed in any of claims 32 to 36, wherein data transmissions between the nodes of the system are based on space division multiple access (SDMA) technique.

38. A data communication system as claimed in any of claims 32 to 37, wherein the capacity parameter for a node defines the number of active data communication links the node may have at a time.

39. A data communication system as claimed in any of claims 32 to 38, wherein the means for communicating control information comprise non-directional antenna means.

40. A data communication system as claimed in any of claims 32 to 39, wherein a node is enabled to be in simultaneous communication with a plurality of nodes during a common timeslot.

41. A data communication system as claimed in any of claims 32 to 40, wherein at least one of nodes comprises a fixedly mounted router node for a data communication network.

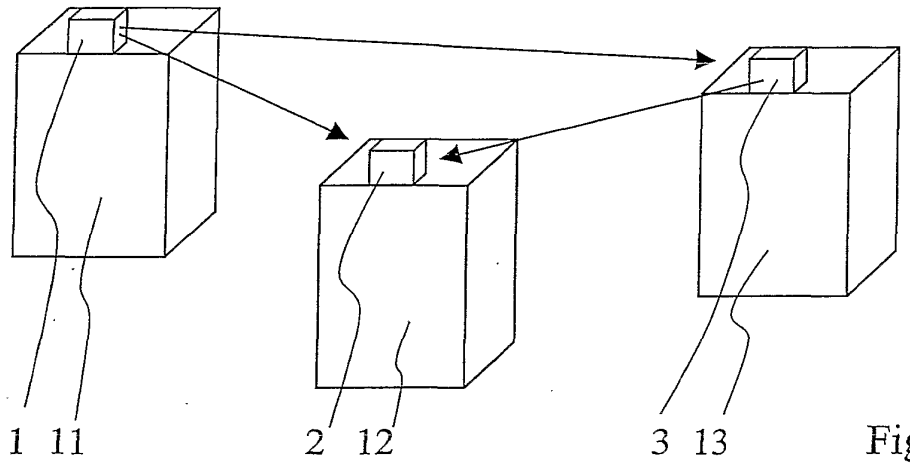


Fig. 1

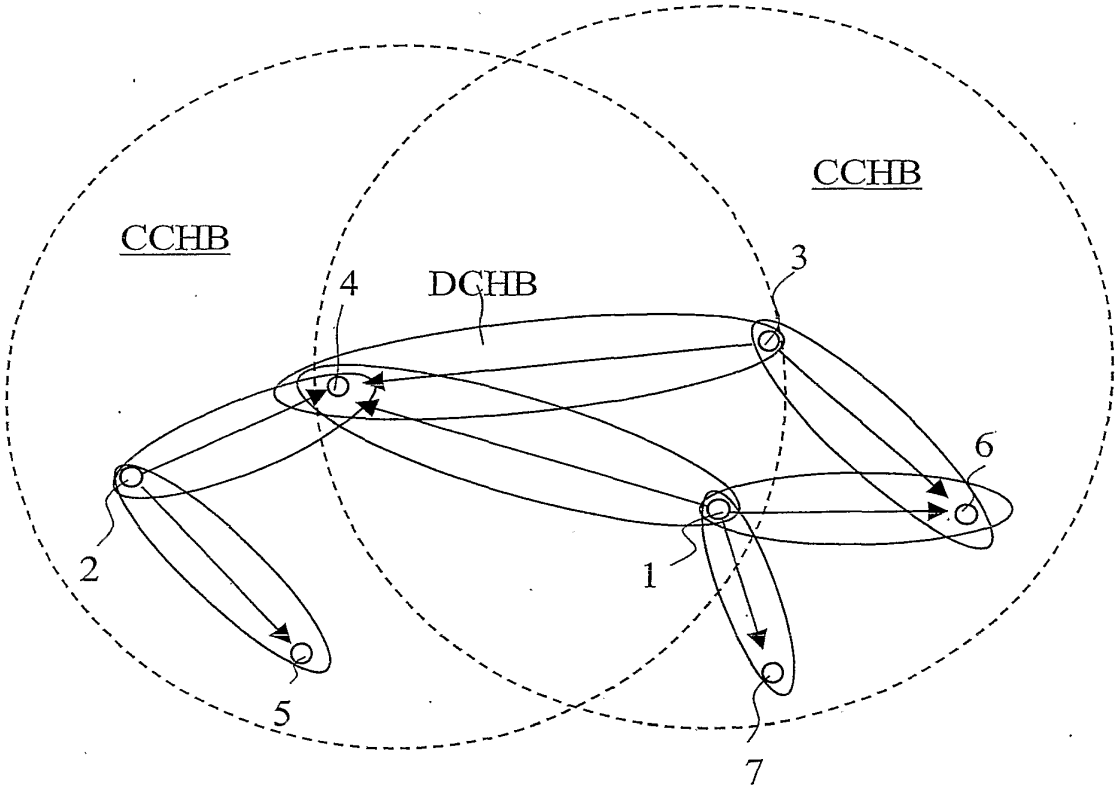


Fig. 2

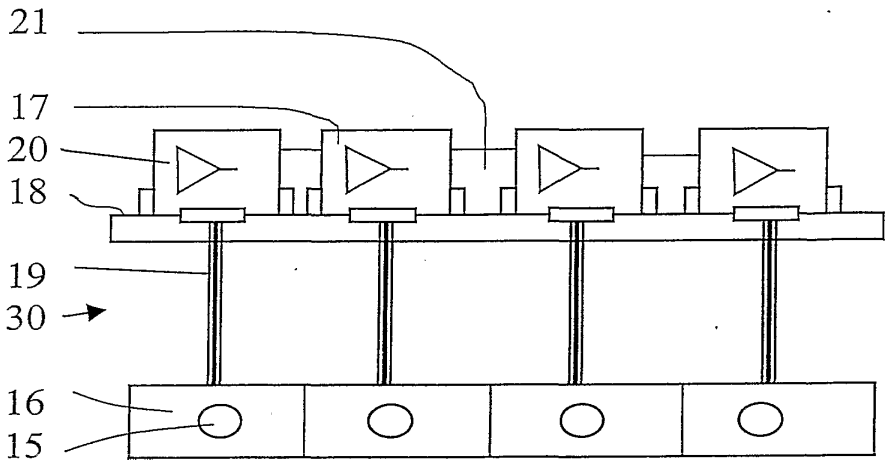

21
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Fig. 3

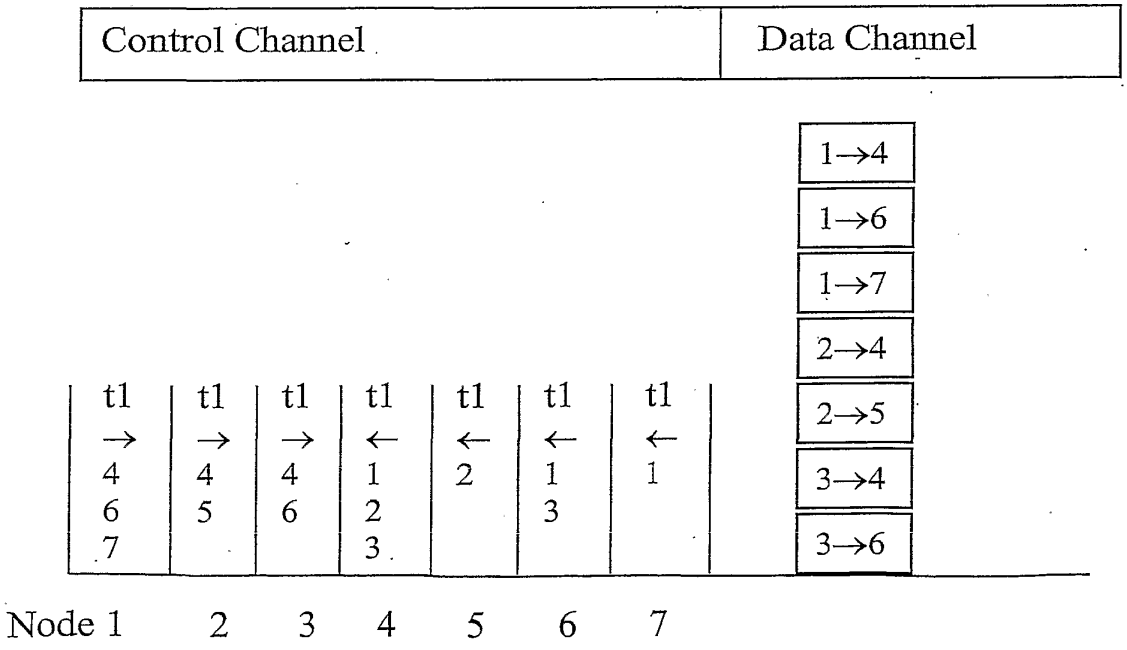
Control Channel
Data Channel
1→4
1→6
1→7
2→4
2→5
3→4
3→6
t1 → 4 6 7
t1 → 4 5
t1 → 4 6
t1 ← 1 2 3
t1 ← 2
t1 ← 1 3
t1 ← 1
Node 1 2 3 4 5 6 7

Fig. 4

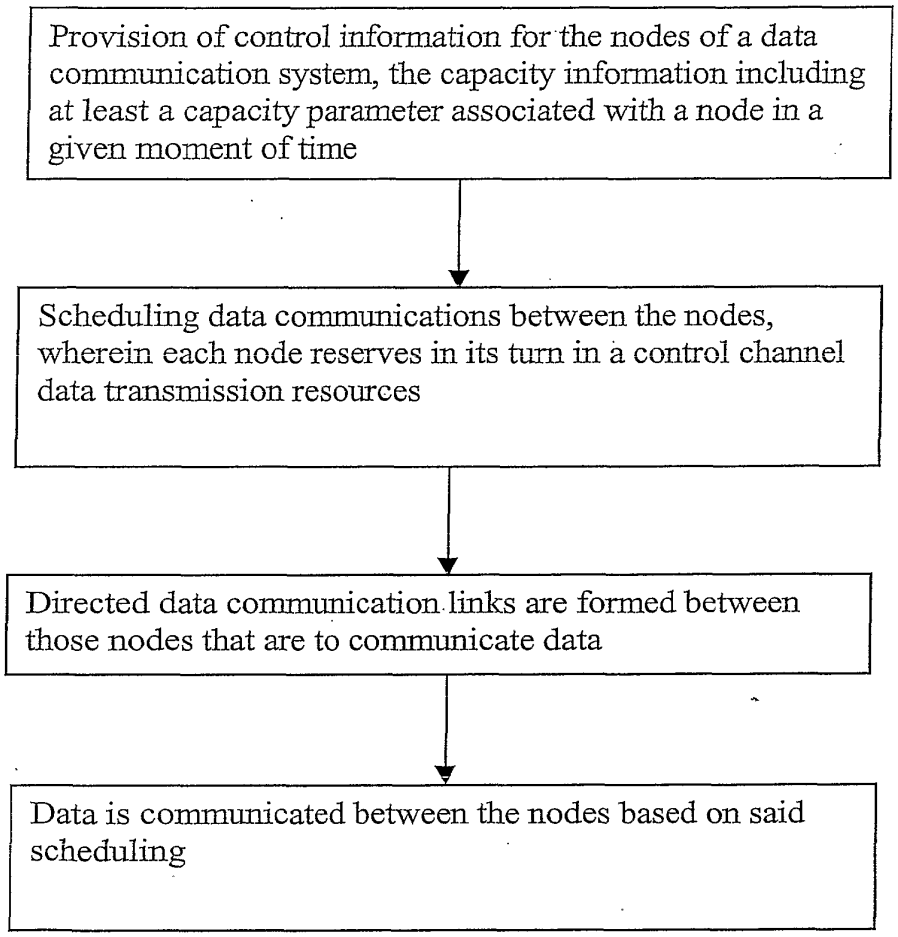
Provision of control information for the nodes of a data communication system, the capacity information including at least a capacity parameter associated with a node in a given moment of time
Scheduling data communications between the nodes, wherein each node reserves in its turn in a control channel data transmission resources
Directed data communication links are formed between those nodes that are to communicate data
Data is communicated between the nodes based on said scheduling

Fig. 5

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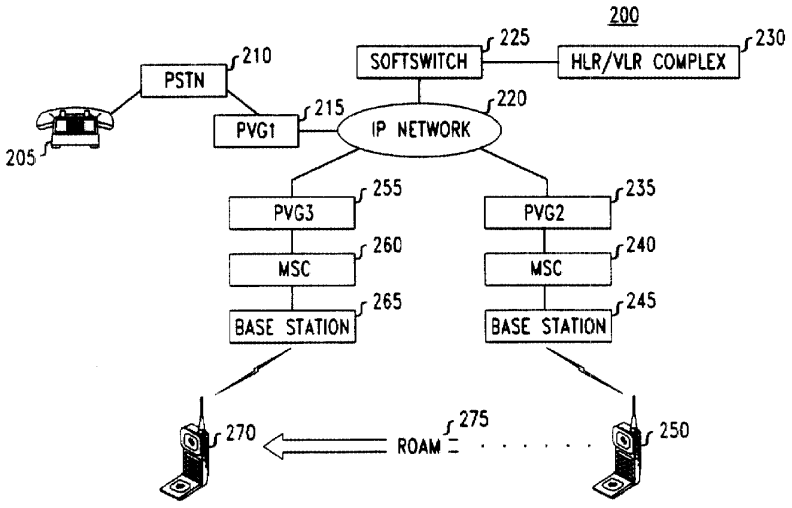
(54) Dynamic routing of wireless communications

(57) A method and apparatus for dynamic routing of wireless communications. More particularly, wireless communications are dynamically routed by marking, by a softswitch, every endpoint participating in a call and as the entry for a marked endpoint is updated a message is generated and sent to the softswitch. Upon receiving such a message, the softswitch re-computes the necessary new resources for maintaining the call and (i) instructs such new resources to negotiate media transfer, (ii) after receiving an acknowledgement from the new resources, transmits appropriate call initiation messages to such resources; and (iii) transmits call release messages to the prior, i.e., old, resources supporting the call. Advantageously, selection of the requisite resources to participate in a particular is driven by the knowledge of the communications network topology. As such, resources are selected which are topologically closer to the endpoint thereby increasing the efficiency of the network resources on a network-wide basis.

FIG. 2



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EP 1 117 270 A2

Description

Field of the Invention

[0001] The present invention relates to wireless communications systems, and more particularly, to dynamically routing calls in wireless communications networks.

Background of the Invention

[0002] A well-known feature of conventional telecommunications systems which provide telephone service, e.g., public switched telephone network (PSTN), central offices (CO), private branch exchange (PBX), and Internet telephony servers, is that such systems are discrete islands of functionality, and each such island has its own particular syntax and semantics. The use of the different syntaxes, semantics, and protocols, makes it difficult to easily interconnect the various islands, and it is virtually impossible to provide features that work together seamlessly across the various islands.

[0003] Further, the increasing growth of wireless communications in terms of both voice and data communications only adds to the above-described network complexity. For example, FIG. 1 shows a conventional wireless communications system architecture 100 as is popular with current day wireless communications service providers. More particularly, wireless communications system architecture 100 includes wireless terminals 110-1 through 110-N, wireless base stations 120-1 through 120-N, mobile switching center (MSC) 130, MSC 140, and public network 150 (e.g., the well-known PSTN).

[0004] As will be readily understood, a user employing a wireless terminal, e.g., wireless terminal 110-1, initiates a call, to a wireless or wireline endpoint, and is connected with a base station, e.g., base station 120-2, which, in turn, routes the call through MSC 130 and public network 150 to the intended endpoint. As such, the PSTN, e.g., public network 150, as it currently exists allows a wireless endpoint, e.g., wireless terminal 110-1, participating in a call with a wireline endpoint to sever its connection with a particular base station, e.g., base station 120-2, and be connected to another base station, e.g., base station 120-1, as the wireless endpoint moves, i.e., roams, within the network. As the base stations are each connected to a MSC and the MSC is connected to a circuit switch in the PSTN, this allows the roaming wireless endpoint to effectively roam within the MSC's immediate network.

[0005] However, the connection between the PSTN and the particular MSC remains fixed for the duration of the call such that call cannot be dynamically (as used herein the terms "dynamic" or "dynamically" mean real-time) routed to a different PSTN circuit switch as the wireless endpoint is roaming in the network. Thus, this leads to problems such as call being "dropped". That is, as the wireless endpoint roams in the network it is connected to various base stations at various times. A certain number of such base stations maintain a connection with a particular MSC. During roaming, a wireless endpoint may find itself connected with a base station which is not associated with the original MSC. Thus, the wireless endpoint is no longer associated with the original MSC and, hence, losses its connection to the PSTN.

[0006] Complicating matters further is that evolution of next generation networks is centered on the convergence of voice and data networks. That is, it appears highly likely that next generation communications network will be an evolution of today's PSTN and Internet Protocol (IP) networks. Today's communications service providers are being driven by a number of factors in the development of such next generation networks such as: (1) the well-known Internet is becoming a major network choice for distribution of voice and data; (2) IP usage is increasing at a dramatic rate thereby causing bandwidth problems on existing PSTN networks carrying significant data traffic; (3) convergence of PSTN and packet networks (e.g., IP networks) is required to allow for end-to-end delivery of communications services; (4) the creation of new services connected with the increasing use of packet networks; and (5) increasing deregulation in the marketplace is creating new and competitive telecommunications environments for established, new, and specialized service providers in both voice and data traffic.

[0007] One major underlying feature in delivering such next generation communications networks is network interoperability. That is, the service providers ability to offer valued added communications services across circuit and packet networks is tied directly to the ability of providing interoperability across a number of heterogeneous networks that support a wide range of signaling protocols (e.g., SS7, IP, Media Gateway Control Protocol (MGCP), H.323, Session Initiation Protocol (SIP) and the like). An emerging switching platform useful in resolving such network interoperability issues is so-called "software switching". Software switches (also known in the art as "softswitches") are a multi-protocol software solution for signaling and transport thereby providing interoperability across heterogeneous networks, e.g., circuit and packet networks. One present commercially available softswitch is the Lucent Technologies Softswitch, available from Lucent Technologies Inc., 600 Mountain Ave., Murray Hill, NJ 07974. In conjunction with the LT Softswitch, PSTN and Internet Telephony Service Providers can provide seamless interoperability between PSTN and IP network domains.

[0008] In these future communications networks, circuit switches that carry telecommunications traffic will be replaced by so-called Packet Voice Gateways (PVG) utilizing packet technology for enabling telecommunications. Essentially, a PVG is a device for converting TDM traffic to IP packets and vice versa. Packet Voice Gateways fall into two main categories: (1) Trunking Gate-

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ways (TG); and (2) Access Gateways (AG). As will be appreciated, the main differences between TG's and AG's is the traffic capacity of each and their respective signaling support. Typically, a TG does not terminate PSTN signaling whereas an AG typically provides integrated services digital network primary rate (ISDN PRI) and other Channel Associated Signaling (CAS) support. In softswitch-controlled networks, both the TG and the AG are controlled via well-known control protocols. In these networks, call setup will be controlled by the softswitch which will instruct PVG's in the network of incoming calls, and the routing of these calls to other PVGs and endpoints. Thus, the softswitch primarily handles the control, i.e., signaling, of data and not voice, i.e., media, traffic which is handled by the PVG. The softswitch instructs the PVG's on how to negotiate with each other and in the efficient handling of the media traffic.

[0009] An aspect of the invention herein is directed to effectively making routing decisions in such networks and, in particular, to facilitating the dynamic routing of wireless communications in such networks.

Summary of the Invention

[0010] An aspect of the present invention is directed to a method and apparatus for dynamic, i.e., in real-time, routing of wireless communications. More particularly, in accordance with an aspect of the invention, wireless communications are dynamically routed by marking, by a softswitch, every endpoint participating in a call and as the entry for a marked endpoint is updated a trigger, e.g., a message, is generated and sent to the softswitch. The generation of such messages will occur under a variety of circumstances, e.g., as a wireless terminal roams to different positions in a network. Upon receiving such a message, the softswitch re-computes an updated set of the necessary network resources for maintaining the call and (i) instructs such updated network resources to negotiate media transfer, that is, a re-negotiation occurs with respect to the handling of the media traffic, i.e., voice traffic, in the that the softswitch determines that a new set of PVG's should handle the media, and instructs such PVG's to re-negotiate the media traffic; (ii) after receiving an acknowledgement from the updated set of resources, the softswitch transmits appropriate call initiation messages to such resources; and (iii) transmits call release messages to the prior, i.e., old, resources supporting the call.

[0011] In accordance with the preferred embodiment of the invention, a call setup request originates from a network, e.g., the well-known SS7 signaling network of the PSTN, and arrives in a packet-switched network that is controlled by a softswitch. In accordance with this preferred embodiment, the softswitch selects a pair of packet voice gateways (PVG1 and PVG2, respectively) to enable media transfer through the packet-switched network and instructs the originating network to direct the media, e.g., the call, to PVG1. Additionally, the softswitch instructs PVG1 and PVG2 to negotiate media transfer between one another, e.g., in a IP network this negotiation will involve well-known RTP/UDP/IP address and port negotiation. Further, PVG2 is instructed to terminate the call on some other network element, e.g., a PSTN circuit switch, a MSC or an endpoint. After the aforementioned PVG negotiation is complete, media transfer is initiated from the originating switch to PVG1, and from PVG1 to PVG2. In accordance with this preferred embodiment, PVG2 is connected to a MSC based on the endpoint's location as defined by a database entry in a well-known Home Location Register (HLR) and/or Visitor Location Register (VLR) (hereafter referred to in combination as a "HLR/VLR complex"). As will be appreciated, HLR's and VLR's play an integral role with MSC's to route a wireless call throughout a wireless network as the endpoints roam in the network.

[0012] As the endpoints roam, in accordance with the preferred embodiment, the corresponding HLR/VLR complex entry is updated. As such updates occur, messages are sent by the HLR/VLR complex to the softswitch which recomputes the necessary new, i.e., updated, resources (e.g., one or more PVG's) for maintaining the call and (i) instructs such new resources to negotiate media transfer, (ii) after receiving an acknowledgement from the new resources, transmits appropriate call initiation messages to such resources; and (iii) transmits call release messages to the prior, i.e., old, resources supporting the call.

[0013] Advantageously, in accordance with an aspect of the invention, selection of the requisite resources to participate in a particular call is driven by the knowledge of the communications network topology. As such, resources are selected which are topologically closer to the endpoint thereby increasing the efficiency of the network resources on a network-wide basis.

Brief Description of the Drawings

[0014]

FIG. 1 shows a conventional wireless communications system architecture;

FIG. 2 shows an exemplary architecture for routing wireless communications in accordance with an embodiment of the invention; and

FIG. 3 is a flowchart of illustrative operations for routing wireless communications in accordance with the principles of the invention.

[0015] Throughout this disclosure, unless otherwise noted, like elements, blocks, components or sections in the figures are denoted by the same reference designations.

Detailed Description

[0016] An aspect of the present invention is directed

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to a method and apparatus for dynamic routing of wireless communications. More particularly, in accordance with an aspect of the invention, wireless communications are dynamically routed by marking, by a softswitch, every endpoint participating in a call and as the entry for a marked endpoint is updated a message is generated and sent to the softswitch. Upon receiving such a message, the softswitch re-computes the necessary new resources for maintaining the call and generates the requisite instructions to such new resources to negotiate and implement media transfer. Advantageously, in accordance with an aspect of the invention, selection of the requisite resources to participate in a particular call is driven by the knowledge of the communications network topology. As such, resources are selected which are topologically closer to the endpoint thereby increasing the efficiency of the network resources on a network-wide basis.

[0017] More particularly, turning our attention to FIG. 2 and FIG. 3, FIG. 2 shows an exemplary architecture 200 for routing wireless communications in accordance with a preferred embodiment of the invention, and FIG. 3 is a flowchart of illustrative operations 300 for routing wireless communications in accordance with the principles of the invention. In particular, in accordance with exemplary architecture 200 and the preferred embodiment, a call is initiated by a calling party from POTS telephone 205 to a called party at wireless terminal 250. As such, a call setup request is initiated (FIG. 3, block 310) and extended through PSTN 210 to a packet-switched network, e.g., IP network 220. IP network 220 is controlled by softswitch 225 which, in accordance with the preferred embodiment, is the aforementioned Lucent Technologies Softswitch, available from Lucent Technologies Inc. (hereinafter alternatively referred to as the "LT Softswitch") A more detailed description of the LT softswitch architecture and its operation is contained in EP-A-0963096 and in EP application no. 00 306 724.6

[0018] Softswitch 225 selects the necessary network resources (see, FIG. 3, block 320). For example, *inter alia.,* a pair of packet voice gateways, in particular, PVG1 215 and PVG2 235 are selected to enable media transfer through IP network 220. Further, softswitch 225 instructs PSTN 210 to direct the media, e.g., the voice traffic, to PVG1 215, and instructs the network resources, e.g., PVG1 215 and PVG2 235, respectively, (see, FIG. 3, block 330) to negotiate media transfer between themselves. For example, in IP networks this negotiation will typically involve well-known RTP/UDP/IP address and port negotiation. Softswitch 225 further instructs PVG2 235 to extend the call to some further network element. In accordance with the instant embodiment, PVG2 235 extends the call to MSC 240 which thereafter, in a conventional manner, completes the wireless call extension through base station 245 to wireless terminal 250. As such, the call is extended from the originating network to the terminating network (see, FIG. 3, block 340).

[0019] In accordance with the embodiment of FIG. 2, PVG2 235 is connected to MSC 240 as a function of the location of wireless terminal 250, i.e., an endpoint, as indicated by its conventional entry in HLR/VLR complex 230. That is, as will be appreciated, HLR/VLR complex 230 contains at least one database storing subscription information with respect to a set of wireless terminals for facilitating communications in a wireless communications network. For example, HLR/VLR complex 230 may contain information about terminals that are currently in a specific wireless service area, or a particular terminal's current location and status. Therefore, the information in HLR/VLR complex 230 changes frequently as subscribers, i.e. endpoints, change location and plays an integral part as roaming occurs in the wireless network.

[0020] As mentioned previously, an aspect of the invention herein is directed to effectively making routing decisions in networks and, in particular, to facilitating the dynamic routing of wireless communications in such networks. That is, an aspect of the present invention is directed to a method and apparatus for dynamic, i.e., in real-time, routing of wireless communications. More particularly, in accordance with an aspect of the invention, wireless communications are dynamically routed by marking, by a softswitch, every endpoint participating in a call and as the entry for a marked endpoint is updated a message is generated and sent to the softswitch. Upon receiving such a message, the softswitch re-computes the necessary new resources for maintaining the call and generates the requisite instructions to such new resources to negotiate and implement media transfer.

[0021] Thus, in accordance with the preferred embodiment, all endpoints participating in a call are marked at the softswitch (see, FIG. 3, block 350). For example, in the illustrative embodiment of FIG. 2, a mark is made at softswitch 225 with respect to POTS telephone 205 and wireless terminal 250. Illustratively, a mark is an entry in a database identifying and describing a particular endpoint. As will be appreciated, the database may be internal to the softswitch or located externally from the softswitch. Now, suppose that the called party using wireless terminal 250 begins to roam. As explained above, such roaming will effect a change in the entry stored in HLR/VLR complex 230. Thus, in accordance with an aspect of the invention, as the entry for a marked endpoint is updated in HLR/VLR complex 230 a message is generated by HLR/VLR complex 230 and transmitted to softswitch 225 (see, FIG. 3, block 360). Upon receiving such a message, softswitch 225 recomputes (see, FIG. 3, block 360) the network resources necessary to maintain or re-establish the particular call. After such recomputation of the requisite network resources is completed, softswitch 225 instructs the updated network resources to negotiate media transfer to maintain/re-establish the call (see, FIG. 3, block 370). Illustrative-

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ly, as such instructions to the updated network resources are received, acknowledgement is received by the softswitch from the updated network resources and the softswitch transmits appropriate call initiation messages (see, FIG. 3, block 370) to the updated resource set. In addition, softswitch 225 will generate call release messages to the old, i.e., no longer required to maintain the call, network resources (see, FIG. 3, block 380).

[0022] As such, resources are selected which are topologically closer to the endpoint thereby increasing the efficiency of the network resources on a network-wide basis. For example, in the illustrative embodiment of FIG. 2, as wireless terminal 250 roams in the network (see, e.g., roaming path 275), softswitch 225, in accordance with an aspect of the invention, is enabled to select those resources which are topologically closer to the endpoint for continuing to maintain the call. Thus, the call originally carried via PVG2 235, MSC 240 and base station 245, is dynamically routed to PVG3 255, MSC 260 and base station 265. Thus, the call is rerouted and extended to wireless terminal 270 without the connection between the PSTN and the particular MSC remaining fixed for the duration of the call such that call can be dynamically routed to a different PSTN circuit switch as the wireless endpoint is roaming in the network. Advantageously, in accordance with an aspect of the invention, selection of the requisite resources to participate in a particular call is driven by the knowledge of the communications network topology thereby increasing overall network efficiency and utilization.

[0023] Of course, while the illustrative embodiment discussed herein includes a single softswitch, it will be understood that the principles of the invention apply to further embodiments involving multiple softswitches thereby providing scalability. For example, in larger size networks it will be necessary to deploy multiple softswitches in order to efficiently process the larger call volume. Such scalability is achieved by employing multiple softswitches which communicate with each other via softswitch-to-softswitch control protocols. Thus, the larger amount of call traffic in the network is distributed across several softswitches. In accordance with such further embodiments of the invention, multiple softswitches may share the same HLR/VLR complex. Thus, messages triggered from the HLR/VLR complex may be routed to a particular softswitch and thereafter routed to other softswitches. Thus, for example, in accordance with such further embodiments of the invention, a wireless endpoint may roam in several networks (operated by different service providers) controlled by multiple softswitches thereby allowing the wireless endpoint to maintain a call across different service provider networks.

[0024] As detailed above, the present invention can be embodied in the form of methods and apparatuses for practicing those methods. The invention can also be embodied in the form of program code embodied in tangible media, such as floppy diskettes, CD-ROMs, hard drives, or any other machine-readable storage medium, wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the invention. The invention can also be embodied in the form of program code, for example, in a storage medium, loaded into and/or executed by a machine, or transmitted over some transmission medium, such as over electrical wiring or cabling, through fiber optics, or via electromagnetic radiation, wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the invention. When implemented on a general-purpose processor, the program code segments combine with the processor to provide a unique device that operates analogously to specific logic circuits.

[0025] Furthermore, all examples and conditional language recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the Applicants to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure.

[0026] Thus, for example, it will be appreciated by those skilled in the art that the block diagrams herein represent conceptual views of illustrative circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flowcharts, flow diagrams, state transition diagrams, pseudocode, program code, and the like represent various processes which may be substantially represented in computer readable medium and so executed by a computer, machine, or processor, whether or not such computer, machine, or processor, is explicitly shown.

Claims

1. A method for routing a call between a first endpoint and a second endpoint in a communications network, the call being extended between the first endpoint and the second endpoint utilizing a first set of network resources, the method comprising:

   marking respective entries in a database related to the first endpoint and the second endpoint, respectively;

   updating the entries in the database as a function of a location of the second endpoint; and

   determining, in response to the updating the

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entries, a second set of network resources for maintaining the call extended between the first endpoint and the second endpoint.

2. The method of claim 1 further comprising:

generating a set of call initiation messages;
transmitting the set of call initiation messages to the second set of network resources; and
routing the call using the second set of network resources.

3. The method of claim 2 further comprising:

generating a set of call release messages; and
transmitting the set of call release messages to the first set of network resources.

4. The method of claim 1 wherein the database is accessible by a softswitch.

5. The method of claim 4 wherein the determining the second set of network resources is performed by the softswitch.

6. The method of claim 5 wherein the updating the entries is performed in response to a message from a HLR/VLR complex, the message identifying the location of the second endpoint.

7. The method of claim 5 wherein the first endpoint includes a POTS telephone and the second endpoint includes a wireless terminal.

8. The method of claim 3 wherein the second set of network resources includes at least a pair of packet voice gateways (PVG).

9. The method of claim 8 wherein the pair of PVG's are used to route the call between a PSTN network and a IP network.

10. A method for maintaining a call extended between a plurality of endpoints in a communications network, the method comprising:

marking respective entries in a communications database related to particular ones of the endpoints utilized to extend the call;
updating the entries in the communications database as a function of a location of at least one endpoint; and
determining, in response to the updating the entries, a set of network resources for maintaining the call extended between the plurality of endpoints.

11. The method of claim 10 further comprising:

routing the call through the set of network resources.

12. The method of claim 11 further comprising:

receiving a message from a HLR/VLR database that identifies that the location of the at least one endpoint has changed.

13. The method of claim 12 wherein the communications network includes at least one PSTN and at least one IP network.

14. The method of claim 13 wherein the second endpoint is a wireless terminal.

15. The method of claim 13 wherein the location of the at least one endpoint is a function of a roaming of the wireless terminal within a geographic region.

16. A communications system for extending a call through a plurality of endpoints comprising:

a communications complex for tracking a location of particular ones of the endpoints; and
at least one softswitch for receiving at least one message from the communications complex, the at least one message being generated as a function of a change in the location of at least one endpoint, and for determining a set of network resources for the extending the call.

17. The communications system of claim 16 wherein the communications complex includes a HLR database.

18. The communications system of claim 17 wherein the communications complex includes a VLR database.

19. The communications system of claim 18 wherein the softswitch receives the message from the HLR database and determines the set of network resources as a function of the message.

20. The communications system of claim 17 wherein the communications system includes at least one PSTN and at least one IP network.

21. The communications system of claim 20 wherein the second endpoint is a wireless terminal.

22. The communications system of claim 21 wherein the wireless terminal is roaming in a geographic region serviced by the communications system.

23. The communications system of claim 22 wherein the change in the location of the at least one endpoint is a function of the roaming of the wireless ter-

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minal within the geographic region.

24. The communications system of claim 20 wherein the softswitch controls the IP network.

25. The communications system of claim 19 wherein the set of network resources includes at least one packet voice gateway.

26. A machine-readable medium having stored thereon a plurality of instructions, the plurality of instructions including instructions that, when executed by a machine, cause the machine to perform a method as claimed in any of claims 1 to 15.

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FIG. 1

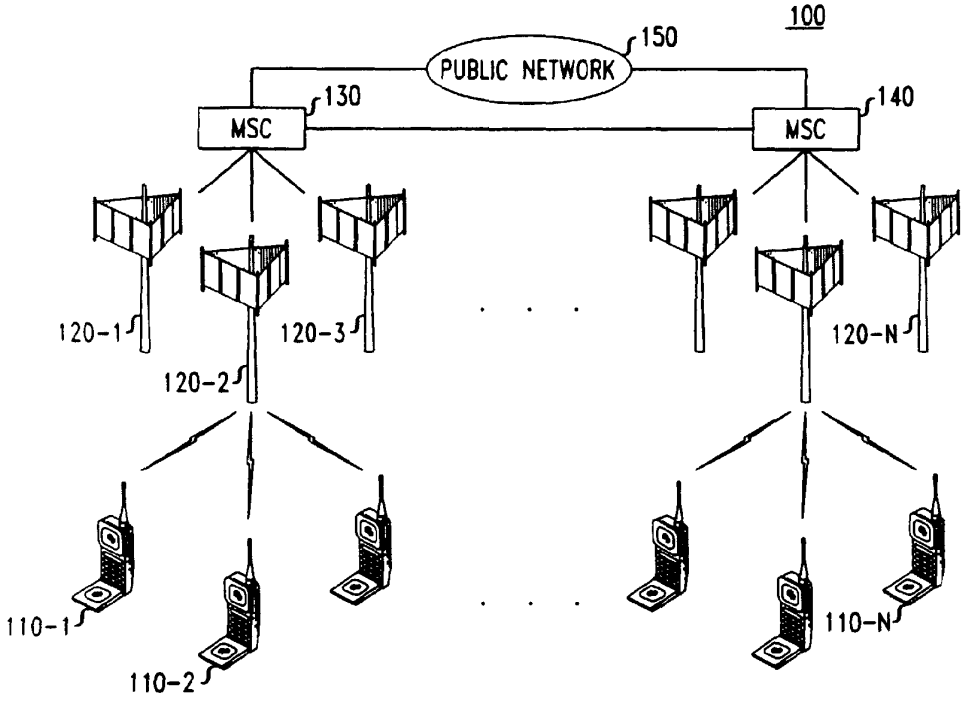

FIG. 2

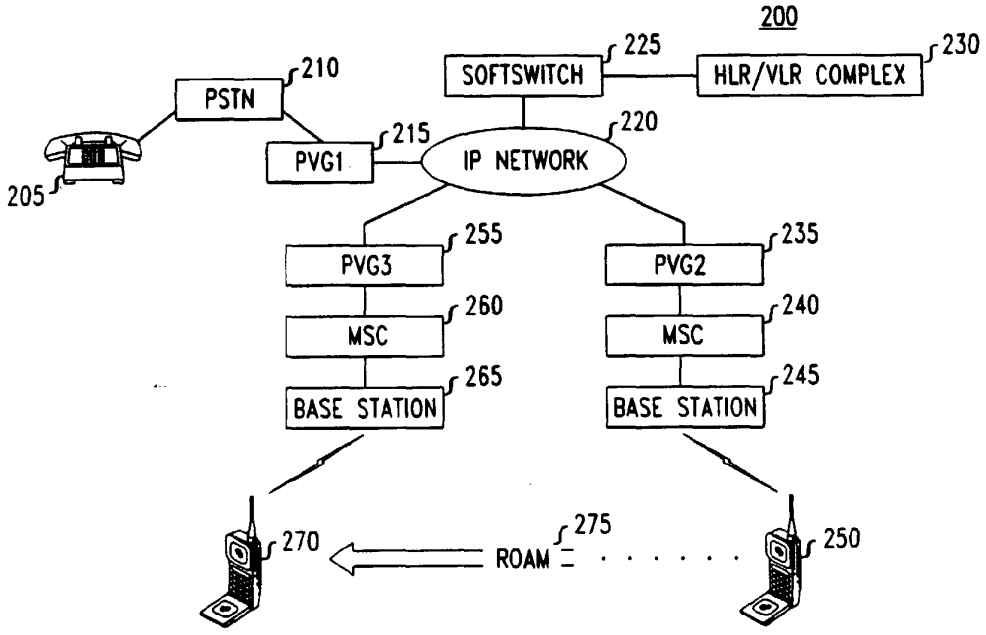

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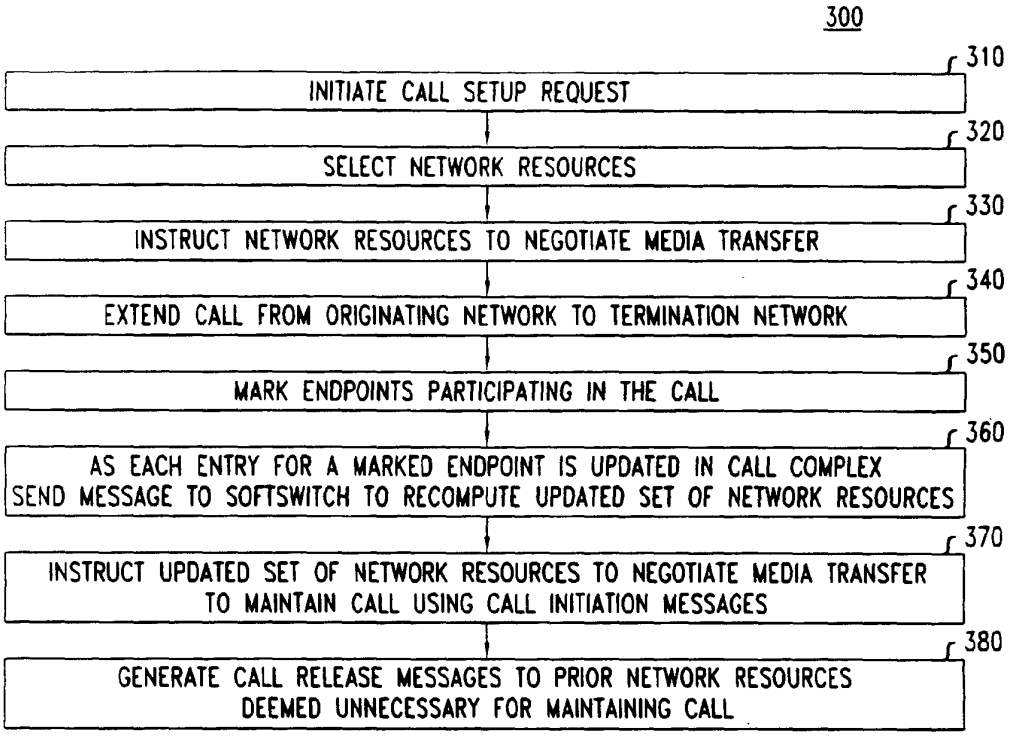
FIG. 3



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Electronic Acknowledgement Receipt

EFS ID:	33112569
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	22145
Filer:	Glen L. Nuttall/Mariel Boyan
Filer Authorized By:	Glen L. Nuttall
Attorney Docket Number:	1640-001.201
Receipt Date:	06-JUL-2018
Filing Date:	12-APR-2017
Time Stamp:	19:35:39
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		1640-001-201--IDSAsFiled07062018.pdf	423364 98732a122670feff1aa12294784f4629e6c79482	yes	6

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	3
	Information Disclosure Statement (IDS) Form (SB08)	4	6

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3	Foreign Reference	WO0038455A1.pdf	1134190 ef8c3c4abe5c466f4fe2ee02d04ba91fab665268	no	33

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Warnings:					
Information:					
23	Non Patent Literature	NPL-JackHWinters_SmartAntennas.pdf	609999 1230acf056e62449bc9e14d983d4301b5e4d6aec	no	15
Warnings:					
Information:					
24	Non Patent Literature	NPL-ConstantineBalanis_ANTENNATHEORY-1.pdf	7080248 36f71c77419eadbe3630fd1cbc7253af45ac8c8c	no	20
Warnings:					
Information:					
25	Non Patent Literature	NPL-JohnLitva_DIGITALBEAMFORMING-1.pdf	20604964 1ef772bcf570c15c207afa331fdc32dc5ae5b051	no	132
Warnings:					
Information:					
26	Non Patent Literature	NPL-IEEEStandardsBearer-1.pdf	1484125 f8226eefbc853302fc5876b28ff18290c14f944b	no	16
Warnings:					
Information:					
27	Non Patent Literature	NPL-SCSwales_ThePerformanceEnhancementofMultibeam-1.pdf	3916330 2143e0a1ad5b6309e91e41a8e4c469b93aa98864	no	17
Warnings:					
Information:					

28	Non Patent Literature	NPL-OliverIbe_EssentialsATMNetworks.pdf	3853288 1dbd7023353fd6ef1b0a0062805d9a5dc5de6052	no	46
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
29	Non Patent Literature	NPL-AndrewTanenbaum_ComputerNetworks.pdf	2887571 26e6107e75a65f48a0751a9a49375a3253e7d980	no	26
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
30	Non Patent Literature	NPL-JohnLitva_DIGITALBEAMFORMING.pdf	19818020 9bbd7c40487ac6ae9038cd560248db2e42f7689c	no	132
Warnings:					
Information:					
31	Non Patent Literature	IPR2018-01016.pdf	2996329 b2fd227858ee7ab5fec6921b5acd476f3bfbba89	no	87
Warnings:					
Information:					
32	Non Patent Literature	IPR2018-01017.pdf	2059700 79a34b7c3cb9a0725c0b41e3b15c9a988f0fbd03	no	79
Warnings:					
Information:					
33	Non Patent Literature	IPR2018-01018.pdf	2300805 3b37e2321d22ebf68ce3f4f1a3a23b9d7d2f5ada	no	65
Warnings:					
Information:					
34	Non Patent Literature	IPR2018-00762--PO_PreliminaryResponse06272018-1.pdf	15752844 6f4d98c6e056731671bc7ba7b1380b2f79ff9e28	no	38

Warnings:					
Information:					
35	Non Patent Literature	IPR2018-00764--PO_PreliminaryResponse06212018-1.pdf	18563044 e86d946e66396d2fa896af95834013798491b2ee	no	47
Warnings:					
Information:					
36	Non Patent Literature	IPR2018-00725--PO_PreliminaryResponse06212018-1.pdf	13800441 5b2a1af4e67bfb2936ad76364395af51fbe8c854	no	35
Warnings:					
Information:					
37	Non Patent Literature	IPR2018-00701--PO_PreliminaryResponse06152018-1.pdf	21056741 88df7544bb3080cbb9230ca32af8e8dfa0dadb0d	no	51
Warnings:					
Information:					
		Total Files Size (in bytes):	247305835		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INFORMATION DISCLOSURE STATEMENT

Applicant	:	Marcus Da Silva
App. No	:	15/486,245
Filed	:	April 12, 2017
For	:	DIRECTED WIRELESS COMMUNICATION
Examiner	:	Sumitra Ganguly
Art Unit	:	2411
Conf No.	:	4888

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Remarks

The present application claims priority to US Ser. No. 60/423,660. Two issued patents – US Pat. Nos. 7,062,296 and 7,729,728 – also claim priority to US Ser. No. 60/423,660, but are otherwise unrelated to the present application. US Pat. No. 6,611,231 is unrelated to the present application, but is owned by the assignee of the present application.

The '296, '728 and '231 patents are currently the subject of litigation in the Central District of California. Also, petitions for Inter Partes Review (IPR) have been filed for each of these patents. Submitted herewith are references and documents taken from each of the IPR proceedings, which include:

For the '296 patent:

- IPR2018-00725
- IPR2018-00764
- IPR2018-01017

For the '728 patent:

- IPR2018-00726
- IPR2018-00763

- IPR2018-01018

For the '231 patent:

- IPR2018-00762
- IPR2018-00701
- IPR2018-01016

Listed below are the pending lawsuits concerning the '231, '296 and '728 patents in the Central District of California:

- XR Communications, LLC, d/b/a Vivato Technologies v. D-Link Systems, Inc., 8:17-cv-0596;
- XR Communications, LLC, d/b/a Vivato Technologies v. Belkin International, Inc., 8:17-cv-00674;
- XR Communications, LLC, d/b/a Vivato Technologies v. Xirrus, Inc., 3:17-cv-00675;
- XR Communications, LLC, d/b/a Vivato Technologies v. Ubiquiti Networks, Inc., 2:17-cv-02968;
- XR Communications, LLC, d/b/a Vivato Technologies v. Ruckus Wireless, Inc., 2:17-cv-02961;
- XR Communications, LLC, d/b/a Vivato Technologies v. NETGEAR, Inc., 2:17-cv-02959;
- XR Communications, LLC, d/b/a Vivato Technologies v. Extreme Networks, Inc., 2:17-cv-02953;
- XR Communications, LLC, d/b/a Vivato Technologies v. Cisco Systems, Inc., 2:17-cv-02951;
- XR Communications, LLC, d/b/a Vivato Technologies v. ASUS Comupter International, et al, 2:17-cv-02948;
- XR Communications, LLC, d/b/a Vivato Technologies v. Newo Corporation d/b/a Amped Wireless, 5:17-cv-00744;

- XR Communications, LLC, d/b/a Vivato Technologies v. Aruba Networks, Inc., 2:17-cv-02945; and
- XR Communications, LLC, d/b/a Vivato Technologies v. ARRIS International plc, et al, 8:18-cv-00192.

Timing of Disclosure

This Information Disclosure Statement is being filed before the receipt of a first Office Action on the merits after filing a request for continued examination under 35 CFR 1.114, and presumably no fee is required. If a first Office Action on the merits was transmitted before the transmittal date of this Information Disclosure Statement, the please charge the appropriate fee to Deposit Account No. 11-1159.

Respectfully submitted,

KLEIN, O'NEILL & SINGH, LLP

Dated: July 6, 2018

By: /Glen L Nuttall/
Glen L. Nuttall
Registration No. 46,188
Attorney of Record

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

22145 7590 10/04/2018

KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

EXAMINER	
GANGULY, SUMITRA	
ART UNIT	PAPER NUMBER
2411	

DATE MAILED: 10/04/2018

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

TITLE OF INVENTION: DIRECTED WIRELESS COMMUNICATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	01/04/2019

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 02/11)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

22145 7590 10/04/2018
KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

TITLE OF INVENTION: DIRECTED WIRELESS COMMUNICATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	01/04/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
GANGULY, SUMITRA	2411	370-329000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

22145 7590 10/04/2018

KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

EXAMINER	
GANGULY, SUMITRA	
ART UNIT	**PAPER NUMBER**
2411	

DATE MAILED: 10/04/2018

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 02/11)

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 15/486,245	Applicant(s) Da Silva et al.	
	Examiner SUMITRA GANGULY	Art Unit 2411	AIA Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 6/20/2018.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1,4-5,7-10,16,19-20,22-25, 31-42 and 44-51 (renumbered 1-34) . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file areply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 7/6/2018.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/S.G/ Examiner, Art Unit 2411	/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application is being examined under the pre-AIA first to invent provisions.

Allowable Subject Matter

2. Claims 1, 4-5, 7-10, 16, 19-20, 22-25, 31-42 and 44-51 are allowed. The following is an examiner's statement of reasons for allowance:

Regarding claim 1, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

....

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

.....

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

Regarding claims 4-5, 7-10, 31-32 and 47-48, these claims depend on claim 1 and thus are allowed for the same reason stated above for claim 1.

Regarding claim 16, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

.....

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

.....

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device, a second transmission peak at a location of the second client device and a first transmission null at a location of a third device.

Regarding claims 19-20, 22-25 and 49-51, these claims depend on claim 16 and thus are allowed for the same reason stated above for claim 16.

Regarding claim 33, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

....

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

.....

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

Regarding claims 34-42, these claims depend on claim 33 and thus are allowed for the same reason stated above for claim 33.

Regarding claim 44, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

.....

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

....

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device, a second transmission peak at a location of the second client device and a first transmission null at a location of a third device.

Regarding claims 45-46, these claims depend on claim 44 and thus are allowed for the same reason stated above for claim 44.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to SUMITRA GANGULY whose telephone number is (571)272-0813. The examiner can normally be reached on 10 a.m to 6 p.m.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Andrew Lai can be reached on 571 272 9741. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SUMITRA GANGULY/
Examiner, Art Unit 2411

/ANDREW LAI/
Supervisory Patent Examiner, Art Unit 2411

Notice of References Cited	Application/Control No. 15/486,245	Applicant(s)/Patent Under Reexamination Da Silva et al.	
	Examiner SUMITRA GANGULY	Art Unit 2411	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8412106-B2	04-2013	da Silva; Marcus	H04B7/04	455/63.4
*	B	US-20040014429-A1	01-2004	Guo, Yingjie Jay	H04B7/0632	455/73
*	C	US-20020158801-A1	10-2002	Crilly, William J. JR.	G01S13/74	342/378
	D					
	E					
	F					
	G					
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	J					
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FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

CPC								
Symbol							**Type**	**Version**
H04B	/	7	/	0617			F	2013-01-01
H04B	/	7	/	04			I	2013-01-01
H04W	/	16	/	28			I	2013-01-01
H04W	/	72	/	046			I	2013-01-01
H04B	/	7	/	0621			I	2013-01-01

CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

/SUMITRA GANGULY/ Examiner, Art Unit 2411	20 September 2018	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ SPE, Art Unit 2411	25 September 2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20180904

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04B	/	7	/	06

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

/SUMITRA GANGULY/ Examiner, Art Unit 2411	20 September 2018	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ SPE, Art Unit 2411	25 September 2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20180904

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	6	10	13	19		28	24	37	34	46				
	2		11	14	20		29	29	38	10	47				
	3		12		21		30	27	39	11	48				
2	4		13	18	22	8	31	28	40	19	49				
3	5		14	15	23	9	32	30	41	20	50				
	6		15	16	24	22	33	31	42	21	51				
7	7	12	16	17	25	23	34		43						
4	8		17		26	25	35	32	44						
5	9		18		27	26	36	33	45						

/SUMITRA GANGULY/ Examiner, Art Unit 2411	20 September 2018	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ SPE, Art Unit 2411	25 September 2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20180904

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/05/2017	01/05/2018	09/20/2018						
1	1	✓	✓	=						
	2	✓	-	-						
	3	✓	-	-						
2	4	✓	✓	=						
3	5	✓	✓	=						
	6	✓	-	-						
7	7	✓	✓	=						
4	8	✓	✓	=						
5	9	✓	✓	=						
6	10	✓	✓	=						
	11	✓	-	-						
	12	✓	-	-						
	13	✓	-	-						
	14	✓	-	-						
	15	✓	-	-						
12	16	✓	✓	=						
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	18	✓	-	-						
13	19	✓	✓	=						
14	20	✓	✓	=						
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26	36		✓	=						
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29	38		✓	=						
27	39		✓	=						
28	40		✓	=						
30	41		✓	=						
31	42		✓	=						

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

CLAIM		DATE								
Final	Original	06/05/2017	01/05/2018	09/20/2018						
	43		✓	-						
32	44		✓	=						
33	45		✓	=						
34	46		✓	=						
10	47			=						
11	48			=						
19	49			=						
20	50			=						
21	51			=						

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

CPC - Searched*		
Symbol	Date	Examiner
H04B7/00, H04W16/28	6/5/17	S.G
H04B7/00, H04W16/28	1/5/18	S.G

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Inventor, Assignee and Teaxt search in EAST. See search history printout for details.	6/5/17	S.G.
Updated search. See search history printout for details.	1/5/18	S.G.
Updated search. See search history printout for details.	09/20/2018	S.G.

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	Text search in EAST across all class and subclass. See search history printout for details.	09/20/2018	S.G.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1218	30	(US-20040066762-$ | US-0066762-$ US-1117270-$ | US-1234567-$ | US-2349045-$ | US-5345599-$ | US-5515378-$ | US-5548813-$ | US-5553074-$ | US-5592490-$ | US-5634199-$ | US-5890067-$ | US-6115427-$ | US-6169759-$ | US-6208858-$ | US-6359923-$ | US-6501955-$ | US-6597678-$ | US-6611231-$ | US-6778988-$ | US-6795409-$ | US-7031266-$ | US-7039441-$ | US-7062296-$ | US-7346365-$ | US-7729728-$)	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:27
S1219	29	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:38
S1220	42	(("CRILLY") near3 ("William")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:39
S1221	63	(("CONLEY") near3 ("Robert")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:39
S1222	97	(("ALAMOUTI") near3 ("Siavash")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:40
S1223	38	(("CASAS") near3 ("Eduardo")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:40
S1224	38	(("CASAS") near3 ("Eduardo")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:40
S1225	294	(("YIN") near3 ("Hujun")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:41
S1226	11	(("JOSE") near3 ("Bobby")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:41
S1227	141	(("CHOI") near3 ("Yang-Seok")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:42
S1228	175	(("TAROKH") near3 ("Vahid")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:42
S1229	14	(("MEHROTRA") near3 ("Praveen")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:42
S1230	32	(("DA") near3 ("SILVA") near3 ("Marcus")).INV.	US-PGPUB; USPAT;	OR	ON	2018/09/24 20:44

			USOCR			
S1231	354	(("BRENNAN") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:44
S1232	9	S1230 and S1220 and S1231 and S1221 and S1222 and S1223 and S1225 and S1226 and S1227 and S1228 and S1229	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:44
S1233	11	"XR COMMUNICATIONS".AS.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:44
S1234	3	S1232 and S1233	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:45
S1235	4	(modify$3 alter$3 chang$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/09/24 20:45
S1236	41	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/09/24 20:46
S1237	1021	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/09/24 20:46
S1238	1204	(transmit$4 send$3 transmission) near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/09/24 20:47
S1239	138	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/09/24 20:47
S1240	254	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/09/24 20:48
S1241	50	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile MS client user device) same (different near2 times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2018/09/24 20:49

			DERWENT; IBM_TDB			
S1242	376	H04B7/00.cpc.	US-PGPUB; USPAT	OR	ON	2018/09/24 20:51
S1243	3740	H04W16/28.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:52
S1244	6522	H04B7/0617.cpc.	US-PGPUB; USPAT	OR	ON	2018/09/24 20:52
S1245	2051	H04B7/04.cpc.	US-PGPUB; USPAT	OR	ON	2018/09/24 20:52
S1246	3765	H04W72/048.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:53
S1247	221	H04B7/0621.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:53
S1248	1807	H04W72/046.cpc.	US-PGPUB; USPAT	OR	ON	2018/09/24 20:55
S1249	43	S1248 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:55
S1250	21	S1247 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:55
S1251	153	S1243 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:56
S1252	165	S1244 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:56
S1253	12	S1245 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:56
S1254	10	S1246 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2018/09/24 20:56
S1255	857	(transmission near3 (maximum peak highest)) with first with second with (UE user client WTRU mobile)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/09/24 20:58
S1256	0	S1218 and S1255	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/09/24 20:59

9/ 24/ 2018 9:37:04 PM
C:\ Users\ sganguly\ Documents\ EAST\ Workspaces\ 15486245_2.wsp

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1257	163	(transmission near3 (maximum peak highest)) with first with second with (UE user client WTRU mobile).clm.	US-PGPUB	OR	ON	2018/09/24 20:37
S1258	16	(transmission with (minimum null) with (maximum peak highest) with feedback).clm.	US-PGPUB	OR	ON	2018/09/24 20:38
S1259	0	S1257 same S1258	US-PGPUB	OR	ON	2018/09/24 20:38

9/24/2018 9:36:17 PM
C:\Users\sganguly\Documents\EAST\Workspaces\15486245_2.wsp

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 1 OF 3	Attorney Docket No.	1640-001.201

U.S. PATENT DOCUMENTS

Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	5,345,599 A	09-06-1994	Paulraj et al.	
	2	5,515,378 A	05-07-1996	Roy, III et al.	
	3	5,548,813 A	08-20-1996	Charas et al.	
	4	5,553,074 A	09-03-1996	Acampora	
	5	5,592,490 A	01-07-1997	Barratt et al.	
	6	5,634,199 A	05-27-1997	Gerlach et al.	
	7	5,890,067 A	03-30-1999	Chang et al.	
	8	6,115,427 A	09-05-2000	Calderbank et al.	
	9	6,169,759 B1	01-02-2001	Kanterakis et al.	
	10	6,208,858 B1	03-27-2001	Antonio et al.	
	11	6,359,923 B1	03-19-2002	Agee et al.	
	12	6,501,955 B1	12-31-2002	Durrant et al.	
	13	6,597,678 B1	07-22-2003	Kuwahara et al.	
	14	6,611,231 B2	08-26-2003	Crilly, Jr. et al.	
	15	6,778,988 B2	08-17-2004	Bengtson	
	16	6,795,409 B1	09-21-2004	Youssefmir et al.	
	17	7,031,266 B1	04-18-2006	Patel et al.	
	18	7,039,441 B1	05-02-2006	Reudink et al.	
	19	7,062,296 B2	06-13-2006	Brennan et al.	
	20	7,346,365 B1	03-18-2008	Hovers et al.	
	21	7,729,728 B2	06-01-2010	Brennan et al.	
	22	2004/0066762 A1	04-08-2004	Alastalo	

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Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	23	GB 2349045 A	10-18-2000	Khalab		
	24	WO 00/038455 A1	06-29-2000	Jetzek		
	25	WO 02/063836 A2	08-15-2002	Alastalo		

Examiner Signature	Date Considered

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G/

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 2 OF 3	Attorney Docket No.	1640-001.201

FOREIGN PATENT DOCUMENTS

Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	26	EP 1117270 A2	07-18-2001	Aravamudan et al.		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	27	Petition for Inter Partes Review of U.S. Patent No. 6,611,231; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00762; pages 1-92.	
	28	Petition for Inter Partes Review of U.S. Patent No. 7,729,728; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00763; pages 1-72.	
	29	Petition for Inter Partes Review of U.S. Patent No. 7,062,296; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00764; pages 1-83.	
	30	Petition for Inter Partes Review of U.S. Patent No. 7,062,296; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00725; pages 1-68.	
	31	Petition for Inter Partes Review of U.S. Patent No. 7,729,728; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; pages 1-53.	
	32	Petition for Inter Partes Review of U.S. Patent No. 6,611,231; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00701; pages 1-76.	
	33	D. Gerlach and A. Paulraj, "*Base Station Transmitter Arrays with Mobile to Base Feedback*," Conference Record of the Twenty-Seventh Asilomar Conference on Signals, Systems& Computers, 1993, pages 1432-36.	
	34	I.A. Glover and P.M. Grant, *Digital Communications*, Prentice Hall Europe, 1998, pages 80-86, § 2.6, "Correlation functions".	
	35	ANSI/IEEE Standard 802.11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, 1999 Edition.	
	36	Z.C. Fluhr and P.T. Porter, "*Advanced Mobile Phone Service: Control Architecture*," Bell System Technical Journal, Vol. 58, No. 1, January 1979, pp 43–69 ("Fluhr")	
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	38	Andrew T. Campbell, et al., "Design, Implementation, and Evaluation of Cellular IP," IEEE PERSONAL COMMUNICATIONS (August 2000).	
	39	Donghee Shim, et al., "Should the Smart Antenna Be A Tracking Beam Array or Switching Beam Array?," 48th IEEE Vehicular Technology Conference (VTC'98) (May 21, 1998).	
	40	Sandra Kay Miller, "Facing the Challenge of Wireless Security," COMPUTER, pp.16-18 (July 2001)	
	41	"Radio Spectrum Allocation," Federal Communications Commission, available at https://www.fcc.gov/engineeringtechnology/policy-and-rules-division/general/radio-spectrumallocation	

Examiner Signature	Date Considered
***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 3 OF 3	Attorney Docket No.	1640-001.201

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	42	IEEE 802.11-1997	
	43	Jack H. Winters, "Smart Antennas," Chapter 6 of WTEC PANEL REPORT ON WIRELESS TECHNOLOGIES AND INFORMATION NETWORKS (July 2000).	
	44	Constantine Balanis, ANTENNA THEORY (1997) (selected pages).	
	45	S.C. Swales, et al., "The Performance Enhancement of Multibeam Adaptive Base-Station Antennas for Cellular Land Mobile Radio Systems," IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, vol. 39, no. 1 (Feb. 1990).	
	46	John Litva, et al., DIGITAL BEAMFORMING IN WIRELESS NETWORKS (1996) (selected pages).	
	47	Joseph C. Liberti, Jr. et al., SMART ANTENNAS FOR WIRELESS COMMUNICATIONS (1999) (selected pages).	
	48	IEEE Standards Bearer (Oct. 1997)	
	49	Petition for Inter Partes Review of U.S. Patent No. 6,611,231; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC, Case No. IPR2018-01016, 87 pages.	
	50	Petition for Inter Partes Review of U.S. Patent No. 7,062,296; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC, Case No. IPR2018-01017, 79 pages.	
	51	Petition for Inter Partes Review of U.S. Patent No. 7,729,728; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC, Case No. IPR2018-01018, 85 pages.	
	52	Oliver C. Ibe, Essentials of ATM Networks and Services, Addison Wesley (1997)	
	53	Andrew S. Tanenbaum, Computer Networks, Third Edition, Prentice Hall (1996)	
	54	Patent Owner's Preliminary Response, CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC, Case No. IPR2018-00762, U.S. Patent No. 6,611,231, 38 pages.	
	55	Patent Owner's Preliminary Response, CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC, Case No. IPR2018-00764, U.S. Patent No. 7,062,296, 47 pages.	
	56	Patent Owner's Preliminary Response, ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00725, U.S. Patent No. 7,062,296, 35 pages.	
	57	Patent Owner's Preliminary Response, ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00701, U.S. Patent No. 6,611,231, 51 pages.	

Examiner Signature	/SUMITRA GANGULY/	Date Considered	09/24/2018

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Request for Continued Examination (RCE) Transmittal

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P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	15/486,245
Filing Date	April 12, 2017
First Named Inventor	Marcus Da Silva
Art Unit	2411
Examiner Name	GANGULY, SUMITRA
Attorney Docket Number	1640-001.201

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

      ii. ☐ Other _____

   b. ☑ Enclosed

      i. ☐ Amendment/Reply

      ii. ☐ Affidavit(s)/ Declaration(s)

      iii. ☑ Information Disclosure Statement (IDS)

      iv. ☐ Other _____

2. Miscellaneous

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☑ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 11-1159.

      i. ☐ RCE fee required under 37 CFR 1.17(e)

      ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17)

      iii. ☐ Other _____

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SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/Glen L Nuttall/	Date	January 4, 2019
Name (Print/Type)	Glen L. Nuttall	Registration No.	46,188

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Signature	/Cindy Chen/		
Name (Print/Type)	Cindy Chen	Date	January 4, 2019

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 1 OF 1	Attorney Docket No.	1640-001.201

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear

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	1	Decision to Institute; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00764; Paper 10; 39 pages.	
	2	Decision Institution of IPR; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01018; Paper 12; 39 pages.	
	3	Decision to Institute; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01017; 41 pages.	
	4	Decision to Institute, ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00725, U.S. Patent No. 7,062,296, 31 pages.	
	5	Decision Instituting IPR; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; Paper 15; pages 33.	
	6	Decision Institution of IPR; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00763; Paper 9; 35 pages.	
	7	Decision to Institute IPR; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00762; Paper 10; 53 pages.	
	8	Decision Denying Institution; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01016; Paper 17; 22 pages.	
	9	Decision Denying Institution, ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00701, U.S. Patent No. 6,611,231, Paper 10; 16 pages.	
	10	Patent Owner's Preliminary Response; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01016; 31 pages.	
	11	Patent Owner's Preliminary Response; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01018; 61 pages.	
	12	Patent Owner's Preliminary Response; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; 33 pages.	
	13	Petitioner's Reply to Patent Owner's Preliminary Response; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; 5 pages.	
	14	Patent Owner's Surr-reply to Petitioner's Reply to Patent Owner's Preliminary Response; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; 6 pages.	
	15	Patent Owner's Preliminary Response; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01017; 61 pages.	
	16	Patent Owner's Preliminary Response; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00763; 40 pages.	

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Electronic Patent Application Fee Transmittal

Application Number:	15486245
Filing Date:	12-Apr-2017
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Filer:	Glen L. Nuttall
Attorney Docket Number:	1640-001.201

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
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Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
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		Total in USD ($)		**950**

Electronic Acknowledgement Receipt	
EFS ID:	34770885
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	22145
Filer:	Glen L. Nuttall
Filer Authorized By:	
Attorney Docket Number:	1640-001.201
Receipt Date:	04-JAN-2019
Filing Date:	12-APR-2017
Time Stamp:	22:24:45
Application Type:	Utility under 35 USC 111(a)

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New International Application Filed with the USPTO as a Receiving Office

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22145 7590 06/19/2019

KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

EXAMINER	
GANGULY, SUMITRA	
ART UNIT	PAPER NUMBER
2411	

DATE MAILED: 06/19/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

TITLE OF INVENTION: DIRECTED WIRELESS COMMUNICATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	09/19/2019

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Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

TITLE OF INVENTION: DIRECTED WIRELESS COMMUNICATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	09/19/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
GANGULY, SUMITRA	2411	370-329000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

22145 7590 06/19/2019

KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

EXAMINER	
GANGULY, SUMITRA	
ART UNIT	**PAPER NUMBER**
2411	

DATE MAILED: 06/19/2019

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 02/11)

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 15/486,245	Applicant(s) Da Silva et al.	
	Examiner SUMITRA GANGULY	Art Unit 2411	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 1/4/2019.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are See Continuation Sheet . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file areply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 1/4/2019.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/SUMITRA GANGULY/ Examiner, Art Unit 2411	/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411

Continuation of 3. The allowed claim(s) is/are: 1, 4-5, 7-10, 16, 19-20, 22-25, 31-42 and 44-51 (renumbered 1-34).

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application is being examined under the pre-AIA first to invent provisions.

Continued Examination Under 37 CFR 1.114

2. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after allowance or after an Office action under *Ex Parte Quayle*, 25 USPQ 74, 453 O.G. 213 (Comm'r Pat. 1935). Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, prosecution in this application has been reopened pursuant to 37 CFR 1.114. Applicant's submission filed on 01/04/2019 has been entered.

Allowable Subject Matter

3. Claims 1, 4-5, 7-10, 16, 19-20, 22-25, 31-42 and 44-51 are allowed. The following is an examiner's statement of reasons for allowance:

Regarding claim 1, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

....

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

.....

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

Regarding claims 4-5, 7-10, 31-32 and 47-48, these claims depend on claim 1 and thus are allowed for the same reason stated above for claim 1.

Regarding claim 16, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

. . . . .

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

. . . . .

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device, a second transmission peak at a location of the second client device and a first transmission null at a location of a third device.

Regarding claims 19-20, 22-25 and 49-51, these claims depend on claim 16 and thus are allowed for the same reason stated above for claim 16.

Regarding claim 33, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

. . . .

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

. . . . .

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

Regarding claims 34-42, these claims depend on claim 33 and thus are allowed for the same reason stated above for claim 33.

Regarding claim 44, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

.....

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

.....

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device, a second transmission peak at a location of the second client device and a first transmission null at a location of a third device.

Regarding claims 45-46, these claims depend on claim 44 and thus are allowed for the same reason stated above for claim 44.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

4. Any inquiry concerning this communication or earlier communications from the examiner should be directed to SUMITRA GANGULY whose telephone number is (571)272-0813. The examiner can normally be reached on 10 a.m to 6 p.m.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Andrew Lai can be reached on 571 272 9741. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SUMITRA GANGULY/
Examiner, Art Unit 2411

/ANDREW LAI/
Supervisory Patent Examiner, Art Unit 2411

Notice of References Cited	Application/Control No. 15/486,245	Applicant(s)/Patent Under Reexamination Da Silva et al.	
	Examiner SUMITRA GANGULY	Art Unit 2411	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8412106-B2	04-2013	da Silva; Marcus	H04B7/04	455/63.4
*	B	US-20040014429-A1	01-2004	Guo, Yingjie Jay	H04B7/0632	455/73
*	C	US-20020158801-A1	10-2002	Crilly, William J. JR.	G01S13/74	342/378
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/05/2017	01/05/2018	09/20/2018	06/10/2019					
1	1	✓	✓	=	=					
	2	✓	-	-	-					
	3	✓	-	-	-					
2	4	✓	✓	=	=					
3	5	✓	✓	=	=					
	6	✓	-	-	-					
7	7	✓	✓	=	=					
4	8	✓	✓	=	=					
5	9	✓	✓	=	=					
6	10	✓	✓	=	=					
	11	✓	-	-	-					
	12	✓	-	-	-					
	13	✓	-	-	-					
	14	✓	-	-	-					
	15	✓	-	-	-					
12	16	✓	✓	=	=					
	17	✓	-	-	-					
	18	✓	-	-	-					
13	19	✓	✓	=	=					
14	20	✓	✓	=	=					
	21	✓	-	-	-					
18	22	✓	✓	=	=					
15	23	✓	✓	=	=					
16	24	✓	✓	=	=					
17	25	✓	✓	=	=					
	26	✓	-	-	-					
	27	✓	-	-	-					
	28	✓	-	-	-					
	29	✓	-	-	-					
	30	✓	-	-	-					
8	31		✓	=	=					
9	32		✓	=	=					
22	33		✓	=	=					
23	34		✓	=	=					
25	35		✓	=	=					
26	36		✓	=	=					
24	37		✓	=	=					
29	38		✓	=	=					
27	39		✓	=	=					
28	40		✓	=	=					
30	41		✓	=	=					
31	42		✓	=	=					

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

CLAIM		DATE								
Final	Original	06/05/2017	01/05/2018	09/20/2018	06/10/2019					
	43		✓	-	-					
32	44		✓	=	=					
33	45		✓	=	=					
34	46		✓	=	=					
10	47			=	=					
11	48			=	=					
19	49			=	=					
20	50			=	=					
21	51			=	=					

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04B7/00, H04W16/28	6/5/17	S.G
H04B7/00, H04W16/28	1/5/18	S.G

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
Inventor, Assignee and Teaxt search in EAST. See search history printout for details.	6/5/17	S.G.
Updated search. See search history printout for details.	1/5/18	S.G.
Updated search. See search history printout for details.	09/20/2018	S.G.
Updated search. See search history printout for details.	06/10/2019	S.G.

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	Text search in EAST across all class and subclass. See search history printout for details.	09/20/2018	S.G.
	Text search in EAST across all class and subclass. See search history printout for details.	06/10/2019	S.G.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

CPC								
Symbol							**Type**	**Version**
H04B	/	7	/	0617			F	2013-01-01
H04B	/	7	/	04			I	2013-01-01
H04W	/	16	/	28			I	2013-01-01
H04W	/	72	/	046			I	2013-01-01
H04B	/	7	/	0621			I	2013-01-01
H04B	/	17	/	318			I	2015-01-15

CPC Combination Sets								
Symbol							**Type**	**Set**	**Ranking**	**Version**
	/		/							

/SUMITRA GANGULY/ Examiner, Art Unit 2411	10 June 2019	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411	13 June 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20190606

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04B	/	7	/	06

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

/SUMITRA GANGULY/ Examiner, Art Unit 2411	10 June 2019	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411	13 June 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20190606

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	6	10	13	19		28	24	37	34	46				
	2		11	14	20		29	29	38	10	47				
	3		12		21		30	27	39	11	48				
2	4		13	18	22	8	31	28	40	19	49				
3	5		14	15	23	9	32	30	41	20	50				
	6		15	16	24	22	33	31	42	21	51				
7	7	12	16	17	25	23	34		43						
4	8		17		26	25	35	32	44						
5	9		18		27	26	36	33	45						

/SUMITRA GANGULY/ Examiner, Art Unit 2411	10 June 2019	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411	13 June 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20190606

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1977	30	((Marcus) near2 ("Da Silva")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:44
S1978	42	(("CRILLY") near3 ("William")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:44
S1979	65	(("CONLEY") near3 ("Robert")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:44
S1980	97	(("ALAMOUTI") near3 ("Siavash")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:44
S1981	38	(("CASAS") near3 ("Eduardo")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:44
S1982	38	(("CASAS") near3 ("Eduardo")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:44
S1983	302	(("YIN") near3 ("Hujun")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:44
S1984	11	(("JOSE") near3 ("Bobby")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:44
S1985	148	(("CHOI") near3 ("Yang-Seok")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S1986	175	(("TAROKH") near3 ("Vahid")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S1987	14	(("MEHROTRA") near3 ("Praveen")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S1988	33	(("DA") near3 ("SILVA") near3 ("Marcus")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S1989	367	(("BRENNAN") near3 ("James")).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S1990	9	S1988 and S1978 and S1989 and S1979 and S1980 and S1981 and S1983 and S1984 and S1985 and S1986 and S1987	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S1991	11	"XR COMMUNICATIONS".AS.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S1992	3	S1990 and S1991	US-PGPUB;	OR	ON	2019/06/08

			USPAT; USOCR			18:45
S1993	4	(modify$3 alter$3 chang$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/08 18:45
S1994	42	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/08 18:45
S1995	1099	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (information) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/08 18:45
S1996	1406	(transmit$4 send$3 transmission) near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/08 18:45
S1997	157	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/08 18:45
S1998	273	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/08 18:45
S1999	65	(transmit$4 send$3 transmission) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile MS client user device) same (different near2 times)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/08 18:45
S2000	429	H04B7/00.cpc.	US-PGPUB; USPAT	OR	ON	2019/06/08 18:45
S2001	4381	H04W16/28.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S2002	7674	H04B7/0617.cpc.	US-PGPUB; USPAT	OR	ON	2019/06/08 18:45
S2003	2306	H04B7/04.cpc.	US-PGPUB; USPAT	OR	ON	2019/06/08 18:45
S2004	4367	H04W72/048.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S2005	258	H04B7/0621.cpc.	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45

S2006	2228	H04W72/046.cpc.	US-PGPUB; USPAT	OR	ON	2019/06/08 18:45
S2007	76	S2006 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S2008	25	S2005 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S2009	212	S2001 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S2010	241	S2002 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S2011	20	S2003 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45
S2012	25	S2004 and ((direct$5 focuss4$ angular$4) near4 beam) and (antenna near4 assembly)	US-PGPUB; USPAT; USOCR	OR	ON	2019/06/08 18:45

6/ 12/ 2019 4:25:17 PM
C:\ Users\ sganguly\ Documents\ EAST\ Workspaces\ 15486245_2.wsp

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S2069	182	(transmission near3 (maximum peak highest)) with first with second with (UE user client WTRU mobile).clm.	US-PGPUB	OR	ON	2019/06/08 18:45
S2070	17	(transmission with (minimum null) with (maximum peak highest) with feedback).clm.	US-PGPUB	OR	ON	2019/06/08 18:45
S2071	0	S2069 same S2070	US-PGPUB	OR	ON	2019/06/08 18:45

6/ 12/ 2019 4:26:20 PM
C:\ Users\ sganguly\ Documents\ EAST\ Workspaces\ 15486245_2.wsp

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 1 OF 1	Attorney Docket No.	1640-001.201

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	1	Decision to Institute; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00764; Paper 10; 39 pages.	
	2	Decision Institution of IPR; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01018; Paper 12; 39 pages.	
	3	Decision to Institute; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01017; 41 pages.	
	4	Decision to Institute, ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00725, U.S. Patent No. 7,062,296, 31 pages.	
	5	Decision Instituting IPR; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; Paper 15; pages 33.	
	6	Decision Institution of IPR; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00763; Paper 9; 35 pages.	
	7	Decision to Institute IPR; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00762; Paper 10; 53 pages.	
	8	Decision Denying Institution; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01016; Paper 17; 22 pages.	
	9	Decision Denying Institution, ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00701, U.S. Patent No. 6,611,231, Paper 10; 16 pages.	
	10	Patent Owner's Preliminary Response; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01016; 31 pages.	
	11	Patent Owner's Preliminary Response; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01018; 61 pages.	
	12	Patent Owner's Preliminary Response; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; 33 pages.	
	13	Petitioner's Reply to Patent Owner's Preliminary Response; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; 5 pages.	
	14	Patent Owner's Surr-reply to Petitioner's Reply to Patent Owner's Preliminary Response; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC, Case No. IPR2018-00726; 6 pages.	
	15	Patent Owner's Preliminary Response; RUCKUS WIRELESS, INC. et al. v. XR COMMUNICATIONS LLC; Case No. IPR2018-01017; 61 pages.	
	16	Patent Owner's Preliminary Response; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS LLC; Case No. IPR2018-00763; 40 pages.	

Examiner Signature	/SUMITRA GANGULY/	Date Considered	06/06/2019

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

~~ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G/~~

T[1] - Place a check mark in this area when an English language Translation is attached.

PTO/SB/30 (11-17)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	15/486,245
Filing Date	April 12, 2017
First Named Inventor	Marcus Da Silva
Art Unit	2411
Examiner Name	GANGULY, SUMITRA
Attorney Docket Number	1640-001.201

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

      ii. ☐ Other _____

   b. ☑ Enclosed

      i. ☐ Amendment/Reply

      ii. ☐ Affidavit(s)/ Declaration(s)

      iii. ☑ Information Disclosure Statement (IDS)

      iv. ☐ Other _____

2. Miscellaneous

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☑ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 11-1159.

      i. ☐ RCE fee required under 37 CFR 1.17(e)

      ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17)

      iii. ☐ Other _____

   b. ☐ Check in the amount of $ _____ enclosed

   c. ☐ Payment by credit card (Form PTO-2038 enclosed)

   d. ■ Payment by EFS-Web

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/Glen L Nuttall/	Date	September 19, 2019
Name (Print/Type)	Glen L. Nuttall	Registration No.	46,188

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being EFS-Web transmitted to the United States Patent and Trademark Office (USPTO), deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop RCE, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450 or facsimile transmitted to the USPTO on the date shown below.

Signature			
Name (Print/Type)		Date	

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 1 OF 1	Attorney Docket No.	1640-001.201

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	6,414,986 B1	07-02-2002	Usui	

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	2	Final Written Decision; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC; Case No. IPR2018-00725; Paper 42; 57 pages.	
	3	Final Written Decision; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS, LLC; Case No. IPR2018-00762; Paper 43; 28 pages.	
	4	Final Written Decision; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS, LLC; Case No. IPR2018-00764; Paper 46; 86 pages.	

Examiner Signature	Date Considered
***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T[1] - Place a check mark in this area when an English language Translation is attached.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Marcus Da Silva et al.	
Title:	DIRECTED WIRELESS COMMUNICATION	
Serial No.:	15/486,245	Filed: April 12, 2017
Examiner:	Sumitra Ganguly	Group Art Unit: 2411
Attorney Docket No.:	1640-001.201	

CERTIFICATE OF EFS-WEB TRANSMISSION
UNDER 37 CFR § 1.8

I hereby certify that the enclosed Request for Continued Examination (1 page); Information Disclosure Statement (1 page); and Payment by Credit Card are being transmitted to the United States Patent and Trademark Office from the Pacific Time Zone via EFS-Web on September 19, 2019.

Date: September 19, 2019

/Mariel Boyan/

Mariel Boyan

Mailing Address:

KLEIN, O'NEILL & SINGH, LLP (Customer No.: 22145)
16755 Von Karman Avenue, Suite 275
Irvine, California 92606
Tel: 949-955-1920
Fax: 949-955-1921

Electronic Patent Application Fee Transmittal

Application Number:	15486245
Filing Date:	12-Apr-2017
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Filer:	Glen L. Nuttall/Mariel Boyan
Attorney Docket Number:	1640-001.201

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
RCE- 2ND AND SUBSEQUENT REQUEST	2820	1	950	950
		Total in USD ($)		**950**

Electronic Acknowledgement Receipt	
EFS ID:	37220159
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	22145
Filer:	Glen L. Nuttall/Mariel Boyan
Filer Authorized By:	Glen L. Nuttall
Attorney Docket Number:	1640-001.201
Receipt Date:	19-SEP-2019
Filing Date:	12-APR-2017
Time Stamp:	19:05:45
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$950
RAM confirmation Number	E20199IJ09215068
Deposit Account	111159
Authorized User	Mariel Boyan
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.17 (Patent application and reexamination processing fees)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		1640-001-201--RCE_IDSasFiled09192019.pdf	201629 a831de13bef07ef1e428a487fb84237a8ca8c30a	yes	3

Multipart Description/PDF files in .zip description

Document Description	Start	End
Request for Continued Examination (RCE)	1	1
Information Disclosure Statement (IDS) Form (SB08)	2	2
Miscellaneous Incoming Letter	3	3

Warnings:

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Information:

2	Non Patent Literature	NPL-IPR2018-00725_FinalWrittenDecision09042019.pdf	2549017 10f3c44d58a67cebaf6c0a374bc72a4d328c19a1	no	57

Warnings:

Information:

3	Non Patent Literature	NPL-IPR2018-00764_FinalWrittenDecision09162019.pdf	4657733 f63a9011a9a528ba5a8bc431f47de0b357f02cc5	no	86

Warnings:

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Information:

4	Non Patent Literature	NPL-IPR2018-00762_FinalWrittenDecision08272019-c.pdf	690626 cf8e5fec3fc306e05ac11ba35aebe80a1bd1219a	no	28

Warnings:

Information:

5	Fee Worksheet (SB06)	fee-info.pdf	30398 8819d413599e0a5fa8623224b268a97852d3d384	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	8129403	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/486,245	Filing Date 04/12/2017	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $40 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $210 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	09/19/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 34	Minus	** 34	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0		x $230 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/SHERRY A DAVIS/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

22145 7590 11/12/2019

KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

EXAMINER	
GANGULY, SUMITRA	
ART UNIT	PAPER NUMBER
2411	

DATE MAILED: 11/12/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

TITLE OF INVENTION: DIRECTED WIRELESS COMMUNICATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	02/12/2020

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PTOL-85 (Rev. 02/11)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

22145 7590 11/12/2019
KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

TITLE OF INVENTION: DIRECTED WIRELESS COMMUNICATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	02/12/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
GANGULY, SUMITRA	2411	370-329000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

22145 7590 11/12/2019

KLEIN, O'NEILL & SINGH, LLP
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IRVINE, CA 92606

EXAMINER	
GANGULY, SUMITRA	
ART UNIT	**PAPER NUMBER**
2411	

DATE MAILED: 11/12/2019

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 02/11)

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 15/486,245	Applicant(s) Da Silva et al.	
	Examiner SUMITRA GANGULY	Art Unit 2411	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 9/19/2019.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are See Continuation Sheet . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 9/19/2019.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/SUMITRA GANGULY/ Examiner, Art Unit 2411	/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411

Continuation of 3. The allowed claim(s) is/are: 1, 4-5, 7-10, 16, 19-20, 22-25, 31-42 and 44-51 (renumbered 1-34).

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application is being examined under the pre-AIA first to invent provisions.

Continued Examination Under 37 CFR 1.114

2. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after allowance or after an Office action under *Ex Parte Quayle*, 25 USPQ 74, 453 O.G. 213 (Comm'r Pat. 1935). Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, prosecution in this application has been reopened pursuant to 37 CFR 1.114. Applicant's submission filed on 09/19/2019 has been entered.

Allowable Subject Matter

3. Claims 1, 4-5, 7-10, 16, 19-20, 22-25, 31-42 and 44-51 are allowed. The following is an examiner's statement of reasons for allowance:

Regarding claim 1, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

. . . .

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

. . . . .

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

Regarding claims 4-5, 7-10, 31-32 and 47-48, these claims depend on claim 1 and thus are allowed for the same reason stated above for claim 1.

Regarding claim 16, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

. . . . .

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

. . . . .

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device, a second transmission peak at a location of the second client device and a first transmission null at a location of a third device.

Regarding claims 19-20, 22-25 and 49-51, these claims depend on claim 16 and thus are allowed for the same reason stated above for claim 16.

Regarding claim 33, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

. . . .

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

. . . . .

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.

Regarding claims 34-42, these claims depend on claim 33 and thus are allowed for the same reason stated above for claim 33.

Regarding claim 44, this claim contains the following underlined features which, when combined with other features of the claim, conventional techniques in the art of record failed to anticipate or render obvious at the time of instant invention was made:

.....

determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information;

.....

wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device, a second transmission peak at a location of the second client device and a first transmission null at a location of a third device.

Regarding claims 45-46, these claims depend on claim 44 and thus are allowed for the same reason stated above for claim 44.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

4. Any inquiry concerning this communication or earlier communications from the examiner should be directed to SUMITRA GANGULY whose telephone number is (571)272-0813. The examiner can normally be reached on 10 a.m to 6 p.m.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Andrew Lai can be reached on 571 272 9741. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SUMITRA GANGULY/
Examiner, Art Unit 2411

/ANDREW LAI/
Supervisory Patent Examiner, Art Unit 2411

Notice of References Cited	Application/Control No. 15/486,245	Applicant(s)/Patent Under Reexamination Da Silva et al.	
	Examiner SUMITRA GANGULY	Art Unit 2411	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8412106-B2	04-2013	da Silva; Marcus	H04B7/04	455/63.4
*	B	US-20040014429-A1	01-2004	Guo, Yingjie Jay	H04B7/0632	455/73
*	C	US-20020158801-A1	10-2002	Crilly, William J. JR.	G01S13/74	342/378
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

CPC								
Symbol							**Type**	**Version**
H04B	/	7	/	0617			F	2013-01-01
H04B	/	7	/	04			I	2013-01-01
H04W	/	16	/	28			I	2013-01-01
H04W	/	72	/	046			I	2013-01-01
H04B	/	7	/	0621			I	2013-01-01
H04B	/	17	/	318			I	2013-01-01

CPC Combination Sets								
Symbol							**Type**	**Set**	**Ranking**	**Version**
	/		/							

/SUMITRA GANGULY/ Examiner, Art Unit 2411	30 October 2019	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411	05 November 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20191025

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04B	/	7	/	06

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

/SUMITRA GANGULY/ Examiner, Art Unit 2411	30 October 2019	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411	05 November 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20191025

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	6	10	13	19		28	24	37	34	46				
	2		11	14	20		29	29	38	10	47				
	3		12		21		30	27	39	11	48				
2	4		13	18	22	8	31	28	40	19	49				
3	5		14	15	23	9	32	30	41	20	50				
	6		15	16	24	22	33	31	42	21	51				
7	7	12	16	17	25	23	34		43						
4	8		17		26	25	35	32	44						
5	9		18		27	26	36	33	45						

/SUMITRA GANGULY/ Examiner, Art Unit 2411	30 October 2019	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/ANDREW LAI/ Supervisory Patent Examiner, Art Unit 2411	05 November 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20191025

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/05/2017	01/05/2018	09/20/2018	06/10/2019	10/31/2019				
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	2	✓	-	-	-	-				
	3	✓	-	-	-	-				
2	4	✓	✓	=	=	=				
3	5	✓	✓	=	=	=				
	6	✓	-	-	-	-				
7	7	✓	✓	=	=	=				
4	8	✓	✓	=	=	=				
5	9	✓	✓	=	=	=				
6	10	✓	✓	=	=	=				
	11	✓	-	-	-	-				
	12	✓	-	-	-	-				
	13	✓	-	-	-	-				
	14	✓	-	-	-	-				
	15	✓	-	-	-	-				
12	16	✓	✓	=	=	=				
	17	✓	-	-	-	-				
	18	✓	-	-	-	-				
13	19	✓	✓	=	=	=				
14	20	✓	✓	=	=	=				
	21	✓	-	-	-	-				
18	22	✓	✓	=	=	=				
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17	25	✓	✓	=	=	=				
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30	41		✓	=	=	=				
31	42		✓	=	=	=				

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	**Art Unit**
	SUMITRA GANGULY	2411

CLAIM		DATE								
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34	46		✓	=	=	=				
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11	48			=	=	=				
19	49			=	=	=				
20	50			=	=	=				
21	51			=	=	=				

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

CPC - Searched*		
Symbol	Date	Examiner
H04B7/00, H04W16/28	6/5/17	S.G
H04B7/00, H04W16/28	1/5/18	S.G

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Inventor, Assignee and Teaxt search in EAST. See search history printout for details.	6/5/17	S.G.
Updated search. See search history printout for details.	1/5/18	S.G.
Updated search. See search history printout for details.	09/20/2018	S.G.
Updated search. See search history printout for details.	06/10/2019	S.G.
Updated search. See search history printout for details.	10/30/2019	S.G.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/486,245	Da Silva et al.
	Examiner	Art Unit
	SUMITRA GANGULY	2411

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	Text search in EAST across all class and subclass. See search history printout for details.	09/20/2018	S.G.
	Text search in EAST across all class and subclass. See search history printout for details.	06/10/2019	S.G.
	Text search in EAST across all class and subclass. See search history printout for details.	10/30/2019	S.G.

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S43	192	(transmission near3 (maximum peak highest)) with first with second with (UE user client WTRU mobile).clm.	US-PGPUB	OR	ON	2019/11/04 19:44
S44	18	(transmission with (minimum null) with (maximum peak highest) with feedback).clm.	US-PGPUB	OR	ON	2019/11/04 19:44
S45	0	S43 and S44	US-PGPUB	OR	ON	2019/11/04 19:44

11/4/2019 7:45:21 PM
C:\Users\sganguly\Documents\EAST\Workspaces\15486245_RCE2.wsp

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	0	((("XR") near3 ("Communications") near3 ("LLC") near3 ("D/B/A") near3 ("Vivato") near3 ("Technologies"))).AS,AANM.	USPAT	OR	OFF	2019/11/04 14:38
S2	33	((("Da") near3 ("Silva") near3 ("Marcus"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:38
S3	29	((("Crilly") near3 ("William") near3 ("J") near3 ("JR"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:38
S4	370	((("Brennan") near3 ("James"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:38
S5	27	((("Conley") near3 ("Robert") near3 ("J"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:38
S6	97	((("Alamouti") near3 ("Siavash"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:38
S7	38	((("Casas") near3 ("Eduardo"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:39
S8	306	((("Yin") near3 ("Hujun"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:39
S9	11	((("Jose") near3 ("Bobby"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:39
S10	154	((("Choi") near3 ("Yang-Seok"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:39
S11	175	((("Tarokh") near3 ("Vahid"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:39
S12	14	((("Mehrotra") near3 ("Praveen"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/11/04 14:39
S13	0	La and S2 and S3 and S4 and S5 and S6 and S7 and S8 and S9 and S10 and S11 and S12	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 14:41
S14	0	S1 and S2 and S3 and S4 and S5 and S6 and S7 and S8 and S9 and S10 and S11 and S12	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2019/11/04 14:42

			IBM_TDB			
S15	9	S2 and S3 and S4 and S5 and S6 and S7 and S8 and S9 and S10 and S11 and S12	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 14:42
S16	0	((("XR") near3 ("Communications") near3 ("LLC") near3 ("D/B/A") near3 ("Vivato") near3 ("Technologies"))).AS.AANM.	USPAT	OR	OFF	2019/11/04 14:42
S17	4	(modify$3 alter$3 chang$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 14:44
S18	43	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3) near3 (antenna near3 beam) with feedback	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 14:45
S19	1171	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with information near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 14:46
S20	0	(transmit$4 send$3 transmission) near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:10
S21	0	(transmit$4 send$3 transmission) near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:11
S22	171	(transmit$4 send$3 transmission) near3 (directional focuss$3) near3 (beam) with (plurality multiple many several second) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:13
S23	1547	(transmit$4 send$3 transmission) near3 (beam) with (UE WTRU mobile client user device) same MIMO	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:14
S24	292	(modify$3 alter$3 chang$3 adjust$3 adapt$3 correct$3 revis$3 reform$3) near3 (beam) with (feedback) near3 (UE WTRU mobile client user device)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:17
S25	83	(transmit$4 send$3 transmission)	US-PGPUB;	OR	ON	2019/11/04

		near3 (beam) with (plurality multiple! many several second) near3 (UE WTRU mobile MS client user device) same (different near2 times)	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			19:18
S26	26224	H04B7/0617.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:21
S27	8243	H04B7/04.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:21
S28	901	H04B7/0621.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:21
S29	19171	H04B17/318.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:22
S30	17036	H04W16/28.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:22
S31	7818	H04W72/046.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:23
S32	226	S26 and ((direct$3 focuss$3 angular$4) near3 beam) and (antenna near3 assembly)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:26
S33	21	S27 and ((direct$3 focuss$3 angular$4) near3 beam) and (antenna near3 assembly)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:27
S34	34	S28 and ((direct$3 focuss$3 angular$4) near3 beam) and (antenna near3 assembly)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:27
S35	31	S29 and ((direct$3 focuss$3	US-PGPUB;	OR	ON	2019/11/04

		angular$4) near3 beam) and (antenna near3 assembly)	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			19:27
S36	215	S30 and ((direct$3 focuss$3 angular$4) near3 beam) and (antenna near3 assembly)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:27
S37	94	S31 and ((direct$3 focuss$3 angular$4) near3 beam) and (antenna near3 assembly)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/11/04 19:27
S46	16	"6414986"	USPAT	OR	ON	2019/11/04 22:38
S47	1	S46 and "S43"	USPAT	OR	ON	2019/11/04 22:40
S48	0	S46 and (transmission near3 (maximum peak highest)) with first with second with (UE user client WTRU mobile)	USPAT	OR	ON	2019/11/04 22:42
S49	0	S46 and (transmission near3 (maximum peak highest)) with first with (another second other) with (UE user client WTRU mobile)	USPAT	OR	ON	2019/11/04 22:42
S50	0	S46 and (transmission with (minimum null) with (maximum peak highest) with feedback)	USPAT	OR	OFF	2019/11/04 22:44

11/4/2019 10:44:56 PM
C:\Users\sganguly\Documents\EAST\Workspaces\15486245_RCE2.wsp

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	15/486,245
	Filing Date	April 12, 2017
	First Named Inventor	Marcus Da Silva
	Art Unit	2411
(Multiple sheets used when necessary)	Examiner	Ganguly, Sumitra
SHEET 1 OF 1	Attorney Docket No.	1640-001.201

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name of Patentee or Applicant	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	6,414,986 B1	07-02-2002	Usui	

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	2	Final Written Decision; ARUBA NETWORKS, INC. v. XR COMMUNICATIONS, LLC; Case No. IPR2018-00725; Paper 42; 57 pages.	
	3	Final Written Decision; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS, LLC; Case No. IPR2018-00762; Paper 43; 28 pages.	
	4	Final Written Decision; CISCO SYSTEMS, INC. v. XR COMMUNICATIONS, LLC; Case No. IPR2018-00764; Paper 46; 86 pages.	

Examiner Signature	/SUMITRA GANGULY/	Date Considered	10/30/2019

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached. ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.G/

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Marcus Da Silva et al.	
Title:	DIRECTED WIRELESS COMMUNICATION	
Serial No.:	15/486,245	Filed: April 12, 2017
Examiner:	Ganguly, Sumitra	Group Art Unit: 2411
Attorney Docket No.:	1640-001.201	

CERTIFICATE OF EFS-WEB TRANSMISSION
UNDER 37 CFR § 1.8

I hereby certify that the enclosed Issue Fee Transmittal (1 page); and Payment by Credit Card are being transmitted to the United States Patent and Trademark Office from the Pacific Time Zone via EFS-Web on February 12, 2020.

Date: February 12, 2020

/Mariel B. Boyan/

Mariel B. Boyan

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Irvine, California 92606
Tel: 949-955-1920
Fax: 949-955-1921

Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

Electronic Patent Application Fee Transmittal

Application Number:	15486245
Filing Date:	12-Apr-2017
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Filer:	Glen L. Nuttall/Mariel Boyan
Attorney Docket Number:	1640-001.201

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	500	500

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**500**

Electronic Acknowledgement Receipt	
EFS ID:	38571433
Application Number:	15486245
International Application Number:	
Confirmation Number:	4888
Title of Invention:	DIRECTED WIRELESS COMMUNICATION
First Named Inventor/Applicant Name:	Marcus Da Silva
Customer Number:	22145
Filer:	Glen L. Nuttall/Mariel Boyan
Filer Authorized By:	Glen L. Nuttall
Attorney Docket Number:	1640-001.201
Receipt Date:	12-FEB-2020
Filing Date:	12-APR-2017
Time Stamp:	17:39:21
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$500
RAM confirmation Number	E20202BH41399141
Deposit Account	111159
Authorized User	Mariel Boyan
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.20 (Post Issuance fees)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		1640-001-201--IssueFeeAsFiled02122020.pdf	143332 d040ff971bc5fbf1d1398494a77b8f789498dc3a	yes	2

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Issue Fee Payment (PTO-85B)	1	1
	Miscellaneous Incoming Letter	2	2

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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30204 635f9865184c6c44408418c6a4d2e00399fdc09a	no	2

Warnings:

Information:

Total Files Size (in bytes):	173536

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

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Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

22145 7590 11/12/2019
KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

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(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	04/12/2017	Marcus Da Silva	1640-001.201	4888

TITLE OF INVENTION: DIRECTED WIRELESS COMMUNICATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0.00	$0.00	$500	02/12/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
GANGULY, SUMITRA	2411	370-329000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Klein, O'Neill & Singh, LLP
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 11-1159

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Glen L. Nuttall/ Date February 12, 2020

Typed or printed name Glen L. Nuttall Registration No. 46,188

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/486,245	03/17/2020	10594376	1640-001.201	4888

22145 7590 02/26/2020

KLEIN, O'NEILL & SINGH, LLP
16755 VON KARMAN AVENUE
SUITE 275
IRVINE, CA 92606

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Marcus Da Silva, Spokane, WA;
XR Communications, LLC D/B/A Vivato Technologies, Solana Beach, CA;
William J. Crilly JR., Liberty Lake, WA;
James Brennan, Sammamish, WA;
Robert J. Conley, Liberty Lake, WA;
Siavash Alamouti, Spokane, WA;
Eduardo Casas, Vancouver, CANADA;
Hujun Yin, Spokane, WA;
Bobby Jose, Veradale, WA;
Yang-Seok Choi, Liberty Lake, WA;
Vahid Tarokh, Cambridge, MA;
Praveen Mehrotra, Spokane, WA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

IR103 (Rev. 10/09)

AO 120 (Rev. 08/10)

TO:		
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-CV-00619	6/16/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	AMAZON.COM, INC., AMAZON.COM SERVICES LLC, EERO LLC, AND RING LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	10,715,235	7/14/2020	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
3		Format m/d/yyyy	
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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DECISION/JUDGEMENT

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Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

AO 120 (Rev. 08/10)

TO:		
	Mail Stop 8 **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

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☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-00621	6/16/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	ARRIS SOLUTIONS, INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,729,728	6/1/2010	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
3		Format m/d/yyyy	
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
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IPR2024-00148

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TO:		
	Mail Stop 8 **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

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☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-00621	6/16/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	ARRIS SOLUTIONS, INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,729,728	6/1/2010	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
3		Format m/d/yyyy	
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

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IPR2024-00148

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Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of TexasWestern District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
	6/16/2021	Western District of TexasWestern District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	ASUSTEK COMPUTER INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,729,728	6/1/2010	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
3	10,715,235	7/14/2020	XR Communications, LLC
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
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IPR2024-00148

AO 120 (Rev. 08/10)

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☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-CV-00624	6/16/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	COMCAST CORPORATION AND COMCAST CABLE COMMUNICATIONS, LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	10,594,376	5/17/2020	XR Communications, LLC
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

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IPR2024-00148

AO 120 (Rev. 08/10)

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	Mail Stop 8 **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-625	6/16/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	GOOGLE LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	10,715,235	7/14/2020	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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IPR2024-00148

AO 120 (Rev. 08/10)

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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
8:21-cv-01064	6/16/2021	Central District of California

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	NETGEAR, INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,729,728	6/1/2010	XR COMMUNICATIONS, LLC
2	10,594,376	3/17/2020	XR COMMUNICATIONS, LLC
3	8,289,939	10/16/2012	XR COMMUNICATIONS, LLC
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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IPR2024-00148

AO 120 (Rev. 08/10)

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Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
8:21-cv-01064	6/16/2021	Central District of California

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	NETGEAR, INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,729,728	6/1/2010	XR COMMUNICATIONS, LLC
2	10,594,376	3/17/2020	XR COMMUNICATIONS, LLC
3	8,289,939	10/16/2012	XR COMMUNICATIONS, LLC
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Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
8:21-cv-1063	6/16/2021	Central District of California

PLAINTIFF	DEFENDANT
XR Communications, LLC, dba Vivato Technologies	D-Link Systems, Inc.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,729,728	6/1/2010	XR Communicatioins LLC
2	10,594,376	3/17/2020	XR Communications, LLC
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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AO 120 (Rev. 08/10)

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Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:21-cv-04912	6/16/2021	Central District of California

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	Aruba Networks, Inc.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,729,728	6/1/2010	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
3	8,289,939	10/16/2012	XR Communications, LLC
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

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IPR2024-00148

AO 120 (Rev. 08/10)

TO:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

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☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-619	6/18/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	AMAZON.COM, INC., AMAZON.COM SERVICES LLC, EERO LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	10,715,235	7/14/2020	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
3		Format m/d/yyyy	
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Ubiquiti Inc. v. XR. Comm.
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☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-623	6/16/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	CISCO SYSTEMS, INC. MERAKI LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,729,728	6/1/2010	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
3	8,289,939	10/16/2012	XR Communications, LLC
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

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Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-626	6/16/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	SAMSUNG ELECTRONICS CO., LTD. AND SAMSUNG ELECTRONICS AMERICA, INC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	10,715,235	7/14/2020	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
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Ubiquiti Inc. v. XR. Comm.
IPR2024-00148

AO 120 (Rev. 08/10)

TO:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-619	6/18/2021	Western District of Texas

PLAINTIFF	DEFENDANT
XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES	AMAZON.COM, INC., AMAZON.COM SERVICES LLC, EERO LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	10,715,235	7/14/2020	XR Communications, LLC
2	10,594,376	3/17/2020	XR Communications, LLC
3		Format m/d/yyyy	
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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
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Ubiquiti Inc. v. XR. Comm.
IPR2024-00148