

four preamble carrier-sets is described here. For those skilled in the art, different values for the FFT size, the left and right guard band sizes, or the number of preamble carrier-sets may be used.

- 5 [0048] In the case of four-sector configuration in which each cell contains four sectors, one way to generate preambles is to divide the entire 1024 subcarriers into four equal subset, arranged in an interlaced manner. Effectively, there are four preamble carrier-sets. The
- 10 subcarriers are modulated, for example, using a level boosted Phase Shift Keying (PSK) modulation with a CAZAC sequence cyclically shifted with a code phase defined by IDcell and Segment, which are the base station identity. More specifically, the four preamble carrier-sets are
- 15 defined using the following formula:

$$PreambleCarrierSet_m = m+4*k \quad (18)$$

- where $PreambleCarrierSet_m$ specifies all subcarriers
- 20 allocated to the specific preamble, m is the number of the preamble carrier-set indexed as 0, 1, 2, or 3, and k is a running index. Each segment of a cell is assigned one of the four possible preamble carrier-sets in this particular example.

- 25 [0049] To further illustrate, let the 1024-FFT OFDMA sampling rate be 20 MHz at the Nyquist rate. The basic preamble time-domain symbol rate is 10MHz. The frequency-domain components are composed of a Chu sequence described in Equations (1) and (2) of length 128 that is zero-inserted to length 512 by
- 30 inserting CAZAC symbols one for every four frequency bins. In the following, it can be established that a time-domain CAZAC sequence at the symbol rate (10MHz) introduces a CAZAC sequence in frequency domain after spectrum folding. Its frequency-domain CAZAC sequence can be computed using a 512-
- 35 FFT operation instead of a 1024-FET operation.

[0050] Let $\mathbf{h}=[h_0, h_1, \dots, h_{2L-1}]^T$ be a time-domain waveform of length $2L$ at the Nyquist rate. Its spectral components can be computed using Equation (14) as follows:

$$5 \quad \mathbf{g}_h = \sqrt{2L} \mathbf{F}_{2L} \mathbf{h} = \begin{bmatrix} \mathbf{g}_{HL} \\ \mathbf{g}_{HU} \end{bmatrix} \quad (19)$$

where \mathbf{F}_{2L} is the Fourier transform matrix of dimension $2L \times 2L$ and \mathbf{g}_{HL} and \mathbf{g}_{HU} are lower and upper portions of the frequency spectrum. When subsampling (i.e., down sampling) the waveform at the mobile station receiver at the symbol rate which is one half of the Nyquist rate, a spectrum folding in the frequency domain is introduced in the sampled signal at the mobile station. Let $\mathbf{h}_E = [h_0, h_2, h_4, \dots, h_{2L-2}]^T$ be the subsampled sequence of the even-numbered samples and $\mathbf{h}_O = [h_1, h_3, h_5, \dots, h_{2L-1}]^T$ the odd-numbered samples. Define \mathbf{S} to be the matrix operation that rearranges matrix columns into even and odd columns:

$$15 \quad \mathbf{S} = [\mathbf{e}_0 \ \mathbf{e}_2 \ \dots \ \mathbf{e}_{2L-2} \ ; \ \mathbf{e}_1 \ \mathbf{e}_3 \ \dots \ \mathbf{e}_{2L-1}]. \quad (20)$$

Therefore,

$$20 \quad \begin{bmatrix} \mathbf{h}_E \\ \mathbf{h}_O \end{bmatrix} = \mathbf{S}^{-1} \mathbf{h} = \frac{1}{\sqrt{2L}} \mathbf{S}^{-1} \mathbf{F}_{2L}^H \begin{bmatrix} \mathbf{g}_{HL} \\ \mathbf{g}_{HU} \end{bmatrix} \quad (21)$$

[0051] When simplified, the following can be derived:

$$25 \quad \mathbf{h}_E = \frac{1}{\sqrt{L}} \mathbf{F}_L^H \left(\frac{\mathbf{g}_{HL} + \mathbf{g}_{HU}}{2} \right) = \frac{1}{\sqrt{L}} \mathbf{F}_L^H \mathbf{g}_{HE} \quad (22)$$

$$\mathbf{h}_O = \frac{1}{\sqrt{L}} \mathbf{F}_L^H \Lambda_\epsilon \left(\frac{\mathbf{g}_{HL} - \mathbf{g}_{HU}}{2} \right) = \frac{1}{\sqrt{L}} \mathbf{F}_L^H \mathbf{g}_{HO} \quad (23)$$

where g_{HE} and g_{HO} are spectral components of the even and odd sample sequences, and $\Lambda_\varepsilon = \text{diag}\{1, \varepsilon, \varepsilon^2, \dots, \varepsilon^{L-1}\}$, $\varepsilon = \exp(j\pi/L)$.

[0052] Equations (22) and (23) can be used to derive the following spectrum folding relationships:

5

$$g_{HE}(k) = \frac{g_{HL}(k) + g_{HU}(k)}{2} \quad (24)$$

$$g_{HO}(k) = \varepsilon^k \left(\frac{g_{HL}(k) - g_{HU}(k)}{2} \right) \quad (25)$$

[0053] Equations (24) and (25) sum up the spectral folding
10 phenomenon of the waveform subsampling of the downlink
preamble signal at the mobile station. Hence, the
subsampling is likely to introduce frequency folding, or
spectrum aliasing. If the subsampling frequency is
sufficiently low when sampling a received preamble sequence
15 in time, the spectral components of the sampled signal
overlap, resulting in the frequency folding. In some
OFDM/OFDMA applications, this phenomenon is intentionally
avoided in order to perfect the signal restoration.

[0054] The spectral folding via sub-sampling at the mobile
20 station receiver, however, may be advantageously used as a
technique to recover the CAZAC property of a unfortunately
truncated CAZAC sequence due to spectral filtering described
above. This is in part based on the recognition that, if
the coherent channel bandwidth is much smaller than the sub-
25 sampled signal bandwidth, there is little adverse effect to
the preamble signals (not true for voice or data signals,
however). As an example, a 1/2 sub-sampling can be used to
intentionally create a "folded" or "aliased" spectrum that
is exactly the CAZAC sequence. By virtue of the time-
30 frequency duality property of a CAZAC sequence, the
corresponding sequence in the time-domain is also a CAZAC
sequence. Although the sub-sampled sequences maintain the
desired CAZAC property, the non-sub-sampled (transmitted)

sequences do not maintain the CAZAC property. For example, the PAPR is about 4.6 dB when the phase rotation shown in FIG. 1B is $\theta = \pi/3$. To achieve lower PAPR, the phase θ can be adjusted to $\pi/4$. Although the "folded spectrum" is no longer an exact CAZAC sequence in the frequency domain, the resulting time domain waveform has a low PAPR of 3.0dB.

[0055] This technique to preserve CAZAC sequence characteristics of the folded frequency spectrum in both frequency and time domains is now further described below.

10 [0056] Following on the above example, the above described construction of the CAZAC sequence in FIGS. 1A and 1B is used to reconstruct the 1024 subcarriers using the 4:1 zero-inserted 512-element frequency-domain CAZAC sequence of a 128-element Chu sequence such that, after the spectrum folding due to the down sampling at the mobile station receiver, the folded 512 spectral components form the frequency-domain CAZAC sequence of the Chu sequence.

15 [0057] Let \mathbf{c}_{chu} denote the time-domain 512-element CAZAC sequence and its frequency-domain CAZAC sequence be denoted as \mathbf{g}_{chu} (512 elements) and expressed as

$$\mathbf{g}_{chu}(4n+k) = \begin{cases} e^{j\frac{\pi n^2}{128}}, & n=0,1,\dots,127, \\ 0, & \text{otherwise} \end{cases} \quad (26)$$

where k denotes the fixed preamble carrier-set. \mathbf{c}_{chu} and \mathbf{g}_{chu} form a time-frequency pair and their relationship is expressed as

$$\mathbf{c}_{chu} = IFFT_{512}(\mathbf{g}_{chu}). \quad (27)$$

25 [0058] In IEEE P802.16e/D3, the 1024-FFT OFDMA has 86 guard subcarriers on the left-hand side and 87 on the right-hand side. The DC (direct current) subcarrier resides on index

512. The construction procedures of assembling \mathbf{g}_L and \mathbf{g}_R of the left- and right-hand sides 1024-FFT OFDMA preambles are

$$\mathbf{g}_R(1:86) = \mathbf{g}_{Chu}(1:86) \quad (28)$$

$$5 \quad \mathbf{g}_R(87:425) = e^{-j\pi/3} \mathbf{g}_{Chu}(87:425) \quad (29)$$

$$\mathbf{g}_R(426:512) = 0 \quad (30)$$

$$\mathbf{g}_L(1:86) = 0 \quad (31)$$

$$\mathbf{g}_L(87:425) = e^{j\pi/3} \mathbf{g}_{Chu}(87:425) \quad (32)$$

$$\mathbf{g}_L(426:512) = \mathbf{g}_{Chu}(426:512) \quad (33)$$

10 In addition, if the DC component is not used, for example in IEEE 802.16 OFDMA system, then

$$\mathbf{g}_R(1) = 0 \quad (34)$$

The final reconstructed 1024-FFT frequency components of the preamble symbol is

15

$$\mathbf{q}(1:1024) = [\mathbf{g}_R(1:512); \mathbf{g}_L(1:512)] \quad (35)$$

and its final reconstructed 1024 time-domain preamble sequence at Nyquist rate is

20

$$\mathbf{c} = \text{IFFT}_{1024}(\mathbf{q}) . \quad (36)$$

[0059] After spectrum folding due to subsampling at symbol rate in the time domain, the resulting folded frequency spectral components of even-numbered samples are, based on Equation (24),

25

$$\mathbf{g}(1:512) \sim \mathbf{g}_L(1:512) + \mathbf{g}_R(1:512) \quad (37)$$

The overlapped area has the following relationship

30

$$\mathbf{g}(87:425) \propto (e^{j\pi/3} + e^{-j\pi/3}) \mathbf{g}_{Chu}(87:425) = \mathbf{g}_{Chu}(87:425) . \quad (38)$$

[0060] Equations (28)-(33) suggest that the CAZAC property is preserved. Note also that overlapped area of odd-numbered samples has the following relationship according to Equation (25):

$$5 \quad g'(87:425) \sim (e^{j\pi/3} - e^{-j\pi/3})g_{chu}(87:425) = j\sqrt{3}g_{chu}(87:425). \quad (39)$$

Therefore, the reconstructed time sequence has the lowest PAPR for the even-numbered sampled sequences and very low PAPR for the odd-numbered sampled sequences that only slightly deviate from the exact CAZAC sequences due to the guard bands requirement. The nominal PAPR of the time-domain sub-sampled sequences is less than 3dB at all different code-phases. The frequency components of the reconstructed 1024-FFT in the preamble sequence have constant amplitudes and thus may be used to facilitate the channel estimation.

[0061] In one implementation, fast cell searching can be performed as follows: The IDCell and Segment allocation to different sector are done via assigning different CAZAC code phases of cyclic shift of the g_{chu} sequence and forming the time-domain sequence in the same manners described in Equations (28)-(36).

[0062] FIG. 4 shows an example of the subcarrier allocations of the preamble sequence in segment 0.

[0063] FIG. 5 shows the corresponding amplitude of the waveform in the time domain. Because the frequency-domain spectral components form a CAZAC sequence, a new sequence formed by cyclically shifting the sequence of the spectral components, in the time domain (subsampling) also forms a CAZAC sequence. Due to the well-defined zero-autocorrelation properties, identifying code-phase and thereby identifying IDcell and segments can be made with optimal decision. The cyclic shifting of the order of different components in the PN sequence permits the MSS to retain one copy of the PN sequence without other shifted sequences. A simple look-up table may be used to provide

the relationships between all sequences based on the cyclic shifting and the corresponding base stations and the associated cell sectors. Therefore, the present technique enables fast cell searching.

5 [0064] A CAZAC sequence has been used for channel sounding whereby the CIR (channel impulse response) can be uniquely determined because of the zero-autocorrelation property of the CAZAC sequence. In OFDMA or OFDM systems, we can use it not only to identify CIR but also to achieve fine timing
10 synchronization whereby we can exclusively remove GI (guard interval) so as to minimize ISI.

[0065] FIG. 6 shows the time waveform of the result of matched filtering of the near-CAZAC sequence (spaced by symbols) without channel distortion and FIG. 7 shows the
15 result of matched filtering of the near-CAZAC sequence in a multipath fading environment. The waveforms are CIRs of the tested RF multipath environment.

[0066] For a sensible and low-cost TCXO, the clock precision is usually about 5ppm for both the base station
20 and the mobile station in some systems. At 10GHz the frequency offset becomes 50kHz. For a 11kHz FFT spacing it spans 5 subcarriers in both directions.

[0067] The near-CAZAC sequence in the frequency domain can be used to simplify identification of peak positions of the
25 cross-correlation. For example, for a sensible and low-cost TCXO, the clock precision is usually about 5ppm (BS+SS). At 10GHz carrier frequency the frequency offset becomes 50kHz.

For an 11kHz FFT spacing it spans 5 subcarriers in both directions. We can assign code phase for different sectors
30 that have different IDCells and segments by at least 10 code phase apart that accommodates ± 5 subcarrier drifts due to large frequency offset, then we can easily perform frequency offset cancellation to within 11kHz. Further fine correction utilizes pilot channel tracking.

[0068] The PAPR of the current preamble design is 4.6dB. The PAPR can be further reduced by selecting different phase factor in Equations (29) and (32). For example, if we change the phase factor in Equations (29) and (32) from $e^{j\pi/3}$ to $e^{j\pi/4}$ as shown in Equations (40) and (41), then PAPR is reduced to 3.0dB by compromising the CAZAC performance.

$$g_R(87:425) = e^{-j\pi/4} g_{Chu}(87:425) \quad (40)$$

$$g_L(87:425) = e^{j\pi/4} g_{Chu}(87:425) \quad (41)$$

10 [0069] Only a few implementations are described. Modifications, variations and enhancements may be made based on what is described and illustrated here.

CLAIMS

What is claimed is:

1. A method for communications based on OFDM or OFDMA, comprising:

5 selecting an initial CAZAC sequence;
 modifying the initial CAZAC sequence to generate a modified sequence which has frequency guard bands; and
 using the modified sequence as part of a preamble of a downlink signal from a base station to a mobile station.

10

2. The method as in claim 1, wherein the initial CAZAC sequence is a Chu sequence.

15 3. The method as in claim 1, wherein the initial CAZAC sequence is a Frank-Zadoff sequence.

20 4. The method as in claim 1, further comprising:
 using an order of frequency components of the preamble sequence to identify a base station transmitter; and
 using different orders of frequency components of the preamble sequence based on a cyclic shift of the orders of frequency components to identify different base station transmitter.

25 5. The method as in claim 4, further comprising using different orders of frequency components of the preamble sequence based on a cyclic shift of the orders of frequency components to further identify different cells sectors in each cell of a base station.

30

6. The method as in claim 1, wherein the modifying of the initial CAZAC sequence comprises:

 selecting frequency components in the initial CAZAC sequence to create the frequency guard bands; and

setting amplitudes of the selected frequency components in the initial CAZAC sequence to zero to create frequency guard bands.

5 7. The method as in claim 6, wherein the modifying of the initial CAZAC sequence further comprises:

adjusting a phase of a selected group of adjacent frequency components in the initial CAZAC sequence whose amplitudes are not changed.

10

8. The method as in claim 1, further comprising:

sub sampling the preamble at a mobile station receiver to create a frequency overlap and to minimize a variation in amplitude.

15

9. A method for communications based on OFDM or OFDMA, comprising:

selecting a CAZAC sequence of a length L in frequency which includes spectral components in first, second and third sequential portions in frequency;

20

modifying the CAZAC sequence to produce a first modified sequence by setting amplitudes of spectral components in the first portion of the CAZAC sequence to zeros and adding a first phase shift on spectral components of the second portion of the CAZAC sequence, without changing the third portion;

25

modifying the CAZAC sequence to produce a second modified sequence by setting amplitudes of spectral components in the third portion of the CAZAC sequence to zeros and adding a second phase shift spectral components of the second portion of the CAZAC sequence, without changing the first portion;

30

combining the first and second modified sequences to form a combined sequence in frequency of a length 2L, wherein the first portion from the first modified sequence

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is positioned next to the third portion from the second modified sequence in the combined sequence; and

performing an inverse fast Fourier transform on the combined sequence to generate a first preamble sequence in
5 time for OFDM or OFDMA communication.

10. The method as in claim 9, further comprising setting widths of the first and third portions of the CAZAC sequence to achieve desired OFDMA guard bands.

10

11. The method as in claim 9, further comprising setting an amplitude of a DC subcarrier to zero when the DC subcarrier is not used.

15

12. The method as in claim 9, further comprising making the first phase shift and second phase shift to be opposite to each other.

13. The method as in claim 9, further comprising:

20

prior to generation of the first and the second modified sequences, performing a cyclic shift of frequency components of an initial CAZAC sequence to produce the CAZAC sequence which is subsequent used to generate the combined sequence; and

25

using an order of the spectral components of the CAZAC sequence to identify at least an identity of a base station which transmits the first preamble sequence as part of a downlink signal.

30

14. The method as in claim 13, further comprising using the cyclic shift of frequency components of the initial CAZAC sequence to generate different orders of the frequency components in frequency to identify at least different base stations and different cell sectors of cells of the

35

different base stations.

15. The method as in claim 9, further comprising:
performing a cyclic shift of time components of the
first preamble sequence to generate a second preamble
sequence.

5

16. The method as in claim 15, further comprising using
the cyclic shift of time components of the initial CAZAC
sequence to generate different orders of the time components
to identify at least different base stations.

10

17. The method as in claim 16, further comprising using
the cyclic shift of time components of the initial CAZAC
sequence to generate different orders of the time components
to represent, in addition to the different base stations,
different cell sectors of cells of the different base
stations.

15

18. The method as in claim 9, wherein the initial CAZAC
sequence is a Chu sequence.

20

19. The method as in claim 9, wherein the initial CAZAC
sequence is a Frank-Zadoff sequence.

20. A method for communications based on OFDM or OFDMA,
comprising:

25

sub sampling a preamble signal in a downlink signal
received at a mobile station receiver to create a frequency
overlap and to minimize a variation in amplitude, wherein
the preamble signal is generated from an initial CAZAC
sequence to preserve properties of the initial CAZAC
sequence and has frequency guard bands; and

30

extracting an order of signal components in the
preamble signal to identify at least a base station at which
the downlink signal is generated.

35

21. The method as in claim 20, wherein the initial CAZAC sequence is a Chu sequence.

22. The method as in claim 20, wherein the initial
5 CAZAC sequence is a Frank-Zadoff sequence.

FIG. 1A

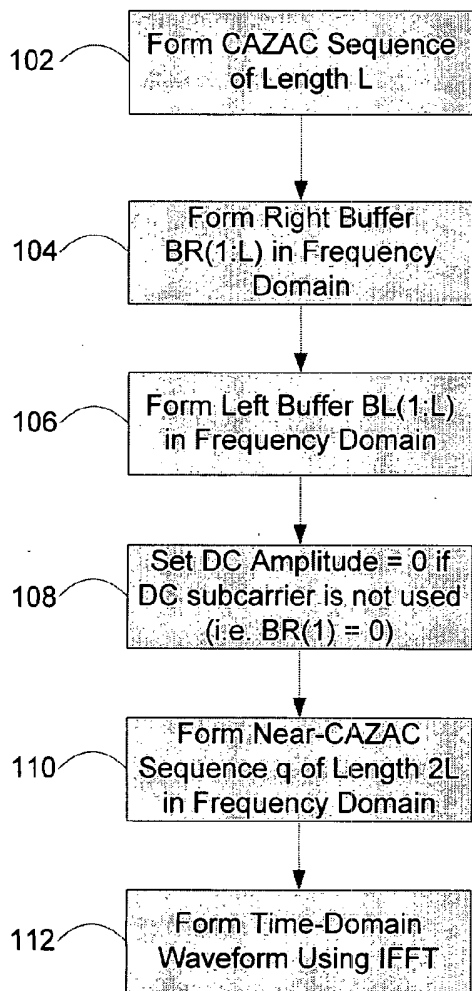


FIG. 1B

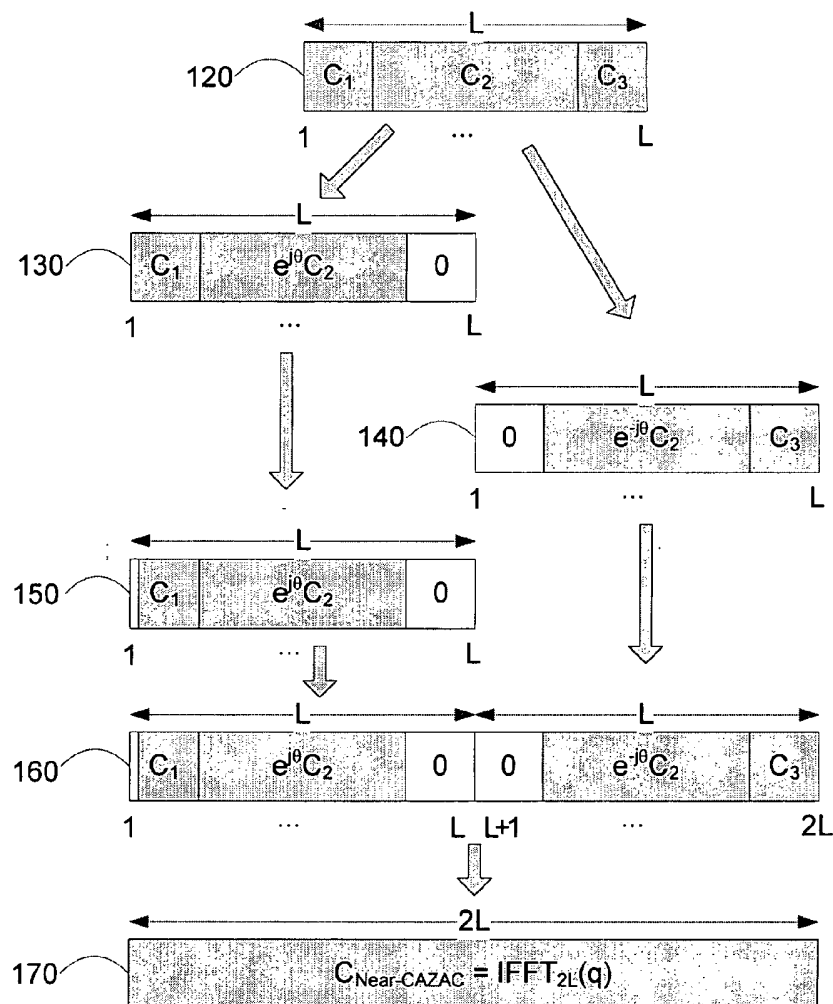


FIG. 2A

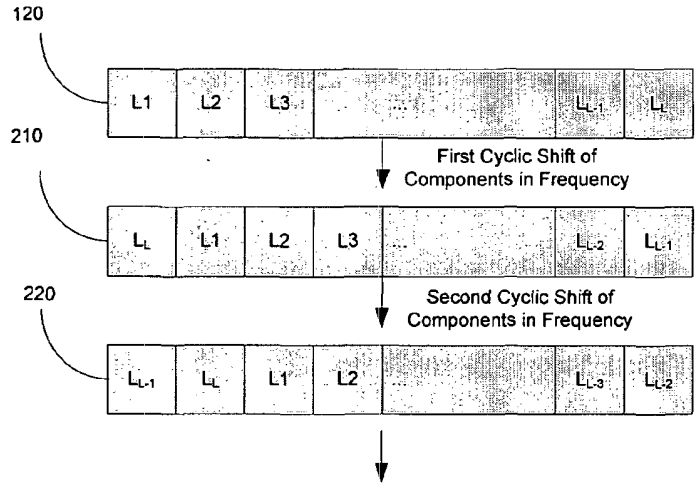


FIG. 2B

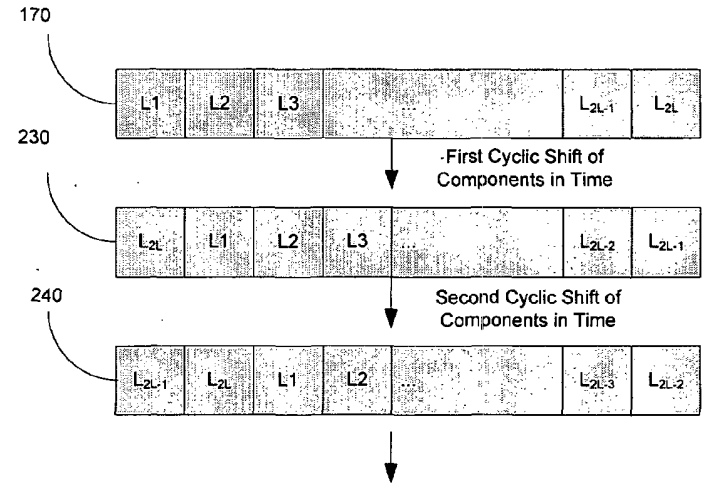


FIG. 3

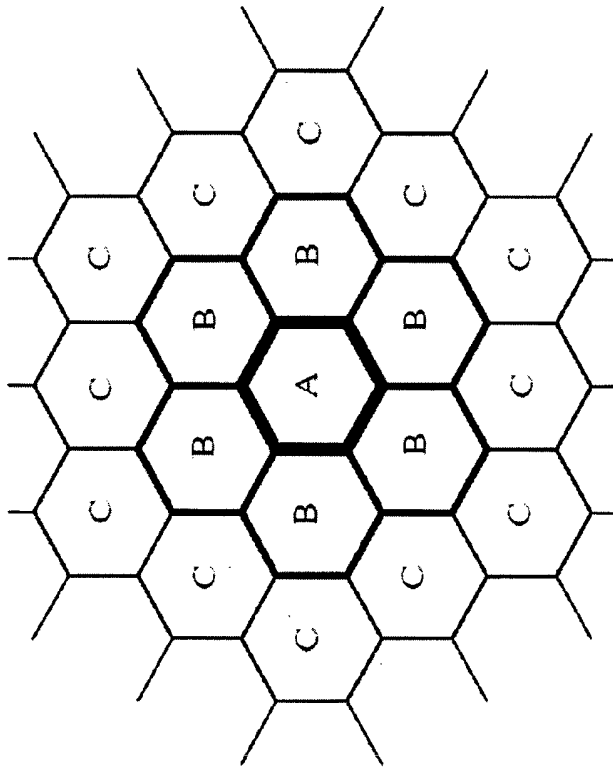


FIG. 4

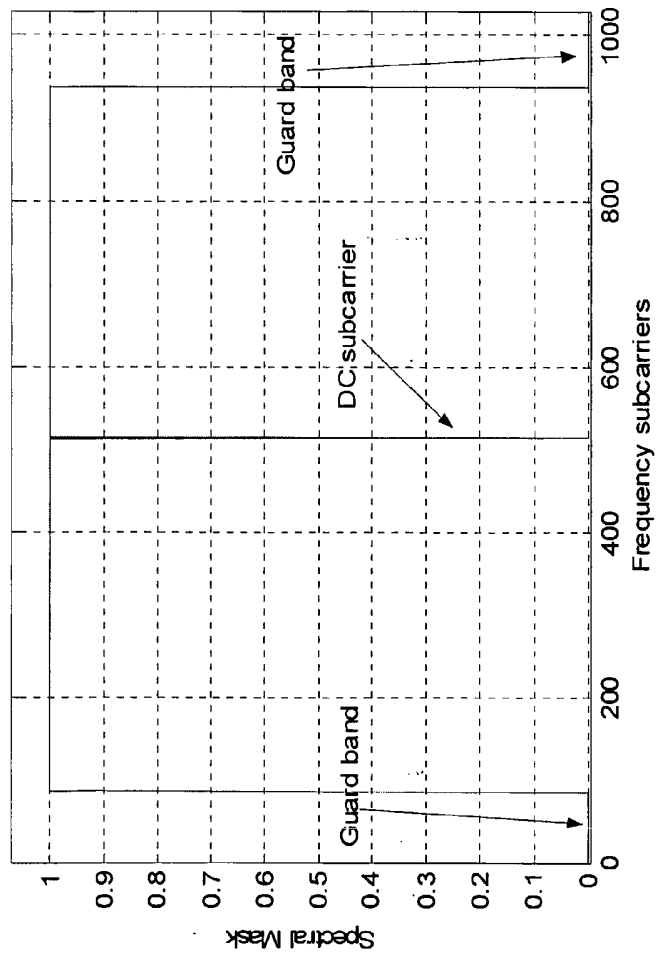


FIG. 5

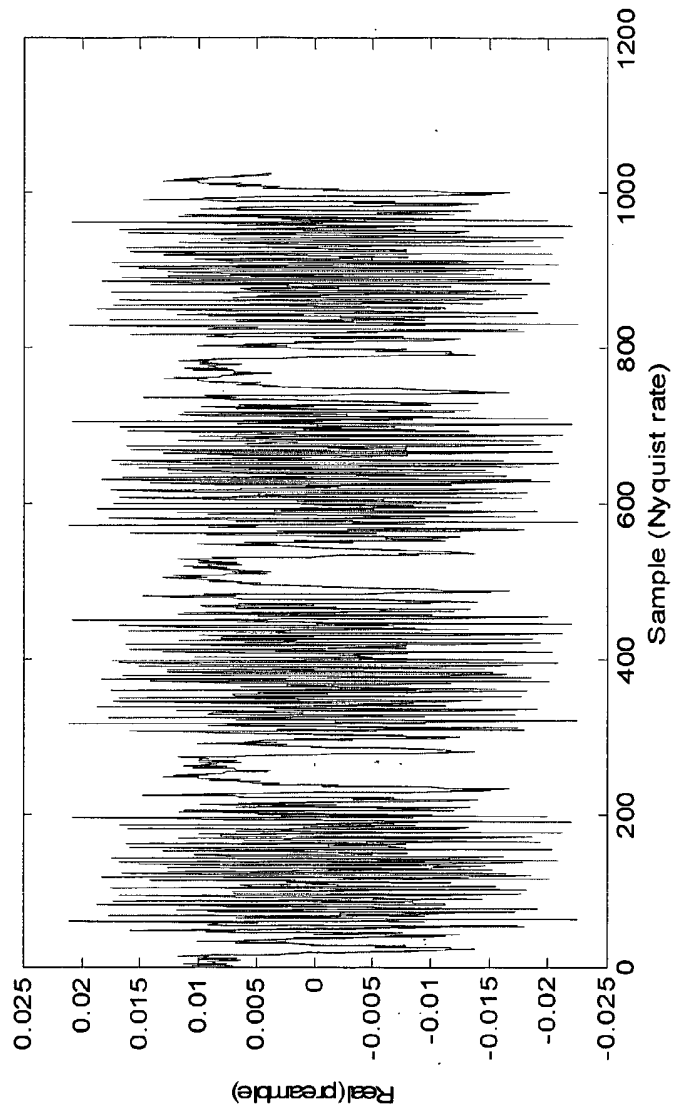


FIG. 6

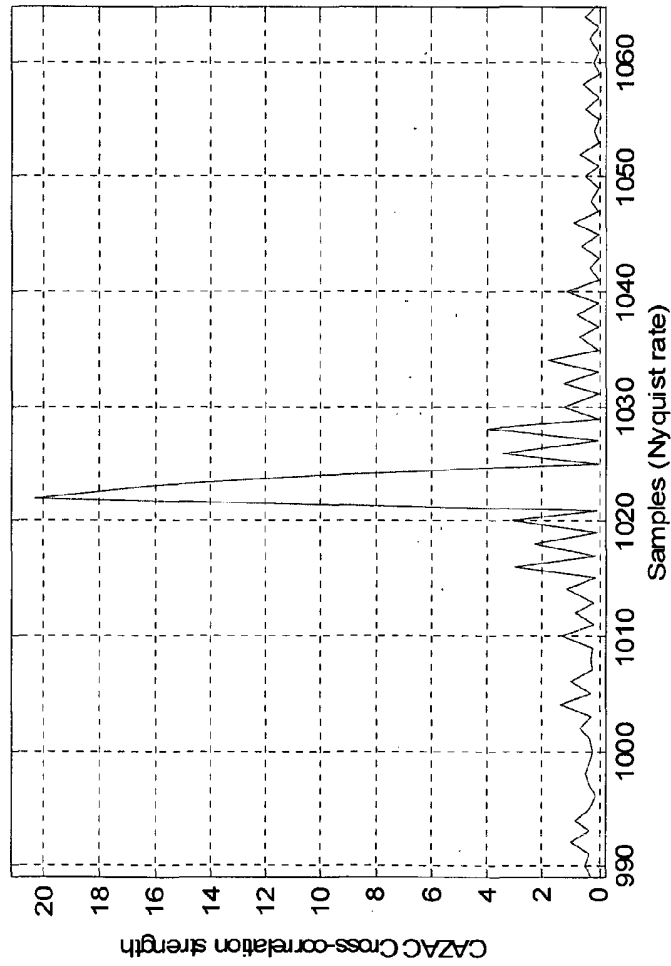
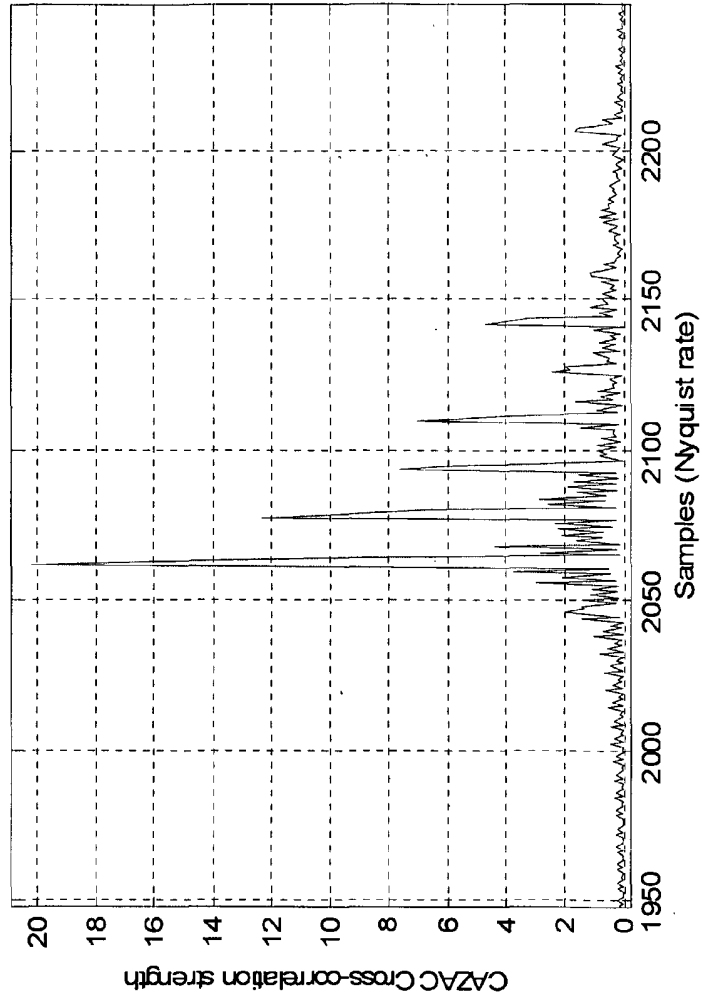


FIG. 7



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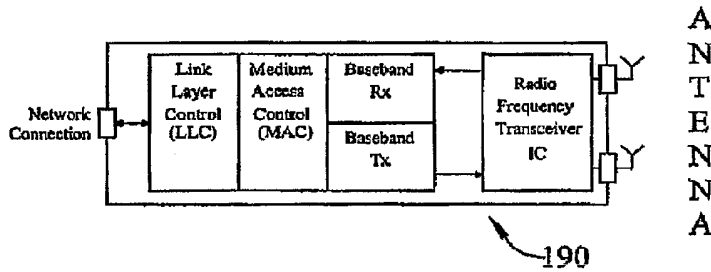
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(54) Title: METHOD AND SYSTEM FOR COMMUNICATION IN A MULTIPLE ACCESS NETWORK



(57) Abstract: The present invention provides an iterative decoding circuit for a wireless multiuser communications receiver comprising a first signal processing means for receiving at least one received signal, said first signal processing means comprising at least two linear iterative filters such that the first linear iterative filter provides an estimate of a selected received signal to an estimated signal output and a second linear iterative filter provides estimates of at least one other received signal, delayed by one iteration cycle, to an input of said first linear iterative filter, a second signal processing means for receiving the estimated signal output of the first linear iterative filter and providing a further received signal estimate to the input of the first signal processing means in a succeeding iteration cycle of the decoding circuit. The application also includes a method of communication with packet sample hypothesis and a method of communicating using estimating time varying channel impairments.

METHOD AND SYSTEM FOR COMMUNICATION IN A MULTIPLE ACCESS NETWORK

RELATED APPLICATIONS

This application claims priority to Australian Provisional Patent Application
5 No. 2003903826, filed 24 July 2003, entitled "An OFDM Receiver Structure", the specification thereof being incorporated herein by reference in its entirety and for all purposes.

FIELD OF INVENTION

The present invention relates to the field of wireless communications. In
10 particular, the present invention relates to improved multiple access communications. In one form, the invention relates to an improved signal processing method and apparatus for a multiple access communication system. It will be convenient to hereinafter describe the invention in relation to the use of an iterative method of determining the reception of a signal in a multi user packet
15 based wireless OFDM (Orthogonal Frequency Division Multiplexing) communication system, however, it should be appreciated that the present invention may not be limited to that use, only. By way of further example, in other forms the present invention may relate to recursive filtering for joint iterative decoding in a variety of systems and functions such as linear multiple access
20 channel decoders, iterative equalisation, iterative joint channel estimation and detection/decoding, iterative space-time processing, iterative multi user interference cancellation and iterative demodulation.

RELATED ART

Throughout this specification the use of the word "inventor" in singular form
25 may be taken as reference to one (singular) or more (plural) inventors of the present invention. The inventor has identified the following related art.

Most wireless communications systems are based on so-called multiple access techniques in which, information such as voice and data are communicated. This is a technology where many simultaneously active users
30 share the same system resources in an organised manner. In most cases, sharing resources in a multiple access system means that if more than one user is active, then all active users interfere with each other. Traditionally, such

interference has been considered to be part of the inevitable noise that corrupts transmissions.

Such interference increases with the number of active users and thus, the performance quality in terms of how many users (capacity) that can share the resources simultaneously becomes limited.

Figure 1 shows an exemplary multiple access scenario that may occur in Wireless Networks. The radio terminals 102, 104 and 100b transmit signals that are received at network access point 100a. In general not all of these signals are intended for radio terminal 100a. They maybe signals from devices that belong to other networks, presumably in unlicensed radio spectrum. In any case there are ordinarily some users of interest that belong to the network to which 100a provides access. The Network aims to make arrangements for all of these signals to be effectively transmitted. Commonly the users may be required to share the radio resource by, for example, transmitting on different frequencies or at different times. Such techniques may be wasteful in terms of the expensive radio resource.

The radio terminal 102 may have an associated user 103 who generates and receives information (in the form of voice, video, data etc). Similarly, the radio terminal 102 is associated with a user. In the case of a vehicular user 105, the vehicle (such as bus, train, or car) may generate and receive data to be communicated over the network. This data may also be generated and received by the passengers and/or operators of the vehicle. The network access point 100b may also wish to communicate with radio terminal 100a as may be the case in wireless backhaul or multihop networks. In this respect, it is also possible that the other users' radio terminals 102, 104 may form part of any multihopping network.

One way to improve capacity is to introduce error control coding. Applying coding allows performance to be improved by only allowing a few of all possible combinations of code symbols to be transmitted. Another way is to exploit the information contained in the interference. This is known as joint multiuser detection. In systems where both these techniques are used, a decoding strategy may be applied which is termed iterative decoding. Here, a multiuser detector first provides an estimate of the transmitted symbols in terms of reliability

information. This information is forwarded to decoders that also provide reliability information based on the input from the detector. Information is then exchanged in an iterative fashion until there are no further improvements. This decoding strategy may increase capacity significantly, getting very close to theoretical capacity limits at a complexity level within reach of practical implementation. However, an optimal multiuser detector is prohibitively complex for practical implementation, as the inherent complexity grows exponentially with the number of active users. Instead, linear multiuser detection based on linear filtering may be applied, where the corresponding complexity only grows linearly with the number of active users. The inventor has identified that for practical reasons related art linear filters for iterative joint multiuser decoding are based on the received signal and the most recent information from the decoders as input to the filter. These filters have been designed based on various optimality criteria.

Where multiple users share common communications resources, access to channel resources may be addressed by a multiple access scheme, commonly executed by a medium access control (MAC) protocol. Channel resources such as available bandwidth are typically strictly limited in a wireless environment. It is therefore desirable to use these resources as efficiently as possible. Allowing multiple users to share common resources creates a risk for disturbances and interference caused by colliding access attempts. Such disturbances are usually referred to as multiple access interference. In wireless local area network (WLAN) systems the MAC attempts to schedule transmissions from Stations in order to avoid collisions. Sometimes the MAC fails, and Stations access the channel resources simultaneously. An example of this situation is illustrated in Figure 2, which shows the transmission of packets from a first transmitter station 1 a second transmitter station 2 and, a representation of received packets at the access point shown on the lowermost line. Physical layer receivers may fail to recover such collided packets. As the traffic load on the network increases, this problem becomes a significant limiting factor in terms of network capacity and quality of service.

A different problem, leading to similar effects, is caused by the multipath nature of communication channels associated with, for example, a WLAN. The multipath channel causes several delayed replicas of the same signal to arrive at

the receiver. This, in turn, creates self-interference similar in nature to multiple access interference discussed above. In this case, the problem becomes a limiting factor for the required power to achieve acceptable performance, which translates into limitations on the coverage of the WLAN. An example of a direct and a reflected version of the original signal arriving at the receiver is shown in Figure 3, where the direct and reflected transmissions of the packet are illustrated on the top two lines as shown. The presence of self interference is indicated by shading in the received signal, represented by the access point on the lowermost line as shown. Transmission range may be affected by the interference mechanisms described above and also by the sophistication of the diversity signal processing at the Receiver. Physical Layer receiver designers therefore strive to ensure that effective use is made of all available time, frequency and space diversity (the latter may be provided through the use of multiple antennas).

The inventor has also identified that when synchronizing transmitted packets over wireless connections each packet ordinarily has a preamble of several repetitions of the same short signal. A received packet signal may be correlated with a delayed version of itself where commonly the delay equals the duration of the repeated signal component in the preamble. This correlation may be implemented repetitively over a given sample sequence. The output power of the resultant correlation may then be combined with the average power of the raw received signal to define a decision statistic. The point at which the decision statistic exceeds a given threshold is selected as the time of arrival of the packet. However, there are drawbacks with this technique in as much as signal distortions may be amplified or accentuated by the processing involved with the synchronization process producing uncertainties in the determination of packet timing.

Generally, in packet based communication systems it is important to reduce latency of a receiver or, in other words, provide as little delay as possible between arrival of signals and the decoding of the bits contained in those signals. Moreover, receiver processes are unable to determine the variation of a radio channel over the time of a packet length and the associated effect on the waveform of the transmitted signal. This may lead to lower than optimum data rates due to poorly tracked packets that are otherwise intact being discarded.

In OFDM packet based communication systems channel impairments may occur, which contribute to changing both the channel over which an OFDM signal travels and also the received signal itself. Collectively, these channel impairments comprise variations in the transmission channel due to multipath fading and, variations to OFDM symbols due to frequency and time offsets caused by receiver inaccuracies and phase offsets due to combined transmission and reception processes. These channel impairments may vary from OFDM symbol to OFDM symbol, in other words, they may not be invariant over the length of a packet. Traditionally, channel impairments are countered by estimates made using a packet preamble and maintained by pilot symbols throughout the received packet, which may assume invariance over the packet length. Other methods use data estimates to aid for example with channel estimation and these are implemented in the frequency domain and may result in power loss by discarding a cyclic prefix for each received symbol. Generally, there is no use made of all available received information to address channel impairments in such packet based communication systems.

With regard to space diversity, for multiple receiving antennae in wireless data packet communication systems related art schemes provide decisions on the synchronization of a received signal on the basis of per antenna and then a majority vote, otherwise the received measurements are added prior to the decision. These approaches do not address the variation of signal statistics across the number of antennae resulting in degraded synchronization accuracy and increased packet loss.

In EP 1387544 it is noted that time synchronisation of a receiver to the incoming signal is essential for effective decoding of that signal. In many packet based applications a special preamble is inserted by the transmitter at the start of every packet transmitted in order to assist the receiver with its timing estimation task. In OFDM systems the transmitter imparts a special structure on the signal called a cyclic prefix. This cyclic prefix is inserted for every OFDM symbol. A cyclic prefix is a replica of a small portion of the last section of a signal inserted at the start of the signal. There are many OFDM symbols transmitted sequentially in most forms of communication. In EP 1387544 the cyclic prefix, in the form of a guard interval as a cyclic continuation of the last part of the active symbol, is

employed to time synchronise the receiver instead of a preamble. In EP 1387544 a two step time synchronisation approach is disclosed, namely a pre-FFT and post-FFT time synchronisation algorithm. These are complementary techniques and may be used together. The pre-FFT technique consists of a "delay and correlate" algorithm applied to find the cyclic prefix of the OFDM symbols. This is achieved by setting the delay in the "delay and correlate" algorithm to the distance between the cyclic prefix and the region from which it was copied. The output of the correlator is then filtered using an auto-regression filter comprising a recursive Infinite-Impulse Response (IIR) filter to determine an average of the correlation across OFDM symbols. A second filtering, by way of smoother 44 in Fig 2 of EP 1387544, is then applied to discard samples outside of the maximum delay measurable, namely, the cyclic prefix duration. However, EP 1387544 relates to a system which makes use of a streaming signal and not readily adapted for the random arrival of packets. In the case of streaming signal, the signal is always there but the fine timing associated with the OFDM symbol boundaries must be determined.

In US 6,327,314 (Cimini, Jr. et al) the problem of tracking the radio channel in a hostile propagation environment is addressed for wireless communications systems using OFDM and one or more antennae for reception. The solution disclosed by Cimini Jr. employs decoder and demodulator outcomes to generate a training or, reference signal, to drive the estimation of the channel for use in decoding the next symbol. The decoding, demodulation and channel estimation loops run according to the paradigm that the channel estimate may use all outcomes up to and including the symbol to be decoded. Each OFDM symbol is decoded once. The raw channel estimate is obtained by multiplying the received OFDM symbol with the training symbols. These training symbols may be from a decoding step. The raw channel estimate, corresponding to one OFDM symbol, is stored in a database. Each time a new OFDM symbol is to be processed all raw estimates in the database are employed to yield the channel estimate at the processing wavefront. In this disclosure the raw channel estimates are stored and a smoothing step is executed every time the data base is accessed, which entails a relative degree of complexity.

In US 6,477,210 (Chuang et al) the problem of tracking the radio channel in a hostile propagation environment is also addressed for wireless communications systems using OFDM and one or more antennae for reception. The solution provided in this disclosure augments that disclosed in US 6,327,314
5 by more clearly disclosing the processing flow and adding a backward recursion to the processing. The backward recursion includes the steps of demodulation, decoding and channel estimation, as in the forward recursion, but the processing commences from the end of the packet. Chuang et al is restricted to Maximum Likelihood decoding systems such as Viterbi decoders. There are many other
10 types of FEC systems that do not employ ML decoding (e.g. Soft Output Decoders such as A-Posterior Probability techniques) and, moreover, for which Chuang is not adapted to operate within.

In a paper by Czylik, A., entitled "Synchronization for systems with antenna diversity", IEEE Vehicular Technology Conference, Vol. 2, 19-22 Sep.
15 1999, pp 728-732 the time and frequency synchronisation of a receiver is considered. In order to successfully decode a packet the receiver must determine the packet time of arrival. Errors in this estimate may result in signal power loss or failures in the synchronisation of high layer structures such as error control coding and FFT windows. Another parameter to be estimated is residual
20 frequency offset. This parameter must be accurately estimated and its effect removed or countered if the packet is to be decoded. Errors in this estimate may result in demodulator failure and subsequent packet decode failure. When a receiver has two antennae there is a possibility to employ these two signals to improve estimation of time and frequency offsets. As disclosed in Czylik,
25 conventional techniques for single antenna exist involving the calculation and subsequent combination of two components. In this paper two main methods are proposed for time and frequency offset estimation. In the first, one antenna is selected, based on received power strength, and conventional techniques are applied to only that signal. In the second method disclosed by Czylik, first and
30 second conventional components are computed for each antenna. The two first components from each antenna are added. The two second components from each antenna are added. The resulting sums are then treated conventionally as a first and second component. The option of weighting each component prior to

combining across antenna according to a signal strength measure for each corresponding antenna is also disclosed in Czylik. This later option is shown to perform better than any of the other proposals in the paper. Filtering of the resulting metric for time synchronisation is also disclosed.

5 Any discussion of documents, devices, acts or knowledge in this specification is included to explain the context of the invention. It should not be taken as an admission that any of the material forms a part of the prior art base or the common general knowledge in the relevant art in Australia, the United States of America or elsewhere on or before the priority date of the disclosure and
10 claims herein.

SUMMARY OF INVENTION

It is an object of the present invention to overcome or mitigate at least one of the disadvantages of related art systems.

In one form the present invention provides an iterative decoding circuit for
15 a wireless multiuser communications receiver comprising:

a first signal processing means for receiving at least one received signal, said first signal processing means comprising at least two linear iterative filters such that:

20 the first linear iterative filter provides an estimate of a selected received signal to an estimated signal output and;

a second linear iterative filter provides estimates of at least one other received signal, delayed by one iteration cycle, to an input of said first linear iterative filter;

25 a second signal processing means for receiving the estimated signal output of the first linear iterative filter and providing a further received signal estimate to the input of the first signal processing means in a succeeding iteration cycle of the decoding circuit.

In another form the present invention provides a method, apparatus and system of communicating in a multiple access network by iteratively receiving
30 multi user signals comprising:

determining a first set of signal estimates for the multi user signals based on linear channel constraints;

determining a second set of signal estimates based on non-linear channel constraints and the first set of signal estimates;

providing the second set of signal estimates as input to the step of determining the first set of signal estimates;

5 repeating the above steps at least once.

In a further form the present invention provides an iterative receiver for receiving multi user signals comprising:

a first signal processing component for determining a first set of signal estimates for the multi user signals based on linear channel constraints;

10 a second signal processing component for receiving the first set of signal estimates and determining a second set of signal estimates based on non-linear channel constraints;

wherein the signal processing components are operatively connected so as to provide the second set of signal estimates as input to the first signal processing component in a succeeding iteration cycle.

15 In another form the present invention provides a method, apparatus and system of communicating in a multiple access network by iteratively receiving OFDM packets comprising:

a) sample a receiver input signal;

20 b) add the input signal with one of a plurality of prior stored received packet sample estimates to determine a packet sample hypothesis;

c) determine an information bit estimate from the sample hypothesis for storage in an information bit estimates list;

d) determine an updated received packet sample estimate from the sample hypothesis for updating the plurality of prior stored estimates;

25 e) subtract the updated sample estimate from the sample hypothesis to determine a noise hypothesis and provide the noise hypothesis as the receiver input signal;

f) repeat steps a) to e) until at least one or more complete packets are accumulated in the information bit estimates list.

30 In yet another form the present invention provides a method, apparatus and system of communicating in a multiple access network by iteratively providing a sample estimates list in an OFDM receiver comprising:

- a) sample a receiver input signal;
- b) determine a packet sample estimate from the sampled receiver input signal;
- c) store the packet sample estimate;
- 5 d) determine a packet sample hypothesis by adding the receiver input with a selected previously stored packet sample estimate;
- e) determine an updated packet sample estimate by decoding and re-transmission modelling the packet sample hypothesis;
- f) update the selected previously stored packet sample estimate with
10 the updated packet sample estimate.

In still another form the present invention provides a method, apparatus and system of communicating in a multiple access network by iteratively providing a packet information bit estimates list in an OFDM receiver comprising:

- a) determine a packet sample hypothesis by adding a receiver input
15 with a selected previously stored packet sample estimate;
- b) determine an information bit estimate by decoding the packet sample hypothesis with one or more of a hard decoding technique and a soft decoding technique
- c) storing the information bit estimate with one or more previously
20 determined information bit estimates;
- d) repeating steps a) to c) until a complete packet is accumulated.

In yet another form the present invention provides a method, apparatus and system of communicating in a multiple access network including determining a hybrid OFDM received packet sample estimate comprising:

- 25 multiplexing a time domain channel application received sample estimate with a frequency domain channel application received sample estimate, such that the multiplexed time domain sample estimate is mapped to correspond to one or more of:
 - an OFDM signal cyclic prefix;
 - 30 an OFDM tail portion, and;
 - an OFDM guard period,
- and wherein the multiplexed frequency domain sample estimate is mapped to correspond to one or more of:

an OFDM signal preamble and;
an OFDM payload data symbol.

In another form the present invention provides a method, apparatus and system of communicating in an OFDM multiple access network comprising:

- 5 performing multi-user interference cancelling which comprises adapting a single pass OFDM receiver to iteratively receive signals at the sampling level so as to allow the receiver to differentiate a desired packet from an observation of an interference signal at the receiver input.

In yet another form the present invention provides a method, apparatus and system of communicating in a multiple access communication network by
10 synchronizing packets arriving at a receiver comprising:

- receiving a packet input signal;
determining a correlation signal corresponding to the packet input signal;
processing the input and correlation signals such that at least one of the
15 input signal and the correlation signal are filtered;
determining a decision statistic by combining a power component of the processed correlation signal with a power component of the processed input signal;

nominate a point in time given by a predetermined threshold condition of
20 the decision statistic as a received packet arrival time.

In yet another form the present invention provides a method, apparatus and system of communicating by tracking time varying channels in a multiple access packet based communication network comprising:

- a) initializing a channel estimate reference based on an initial channel
25 estimate in a received packet preamble;
b) updating the channel estimate reference based on a packet data symbol channel estimate in a coded portion of the current and all prior received data symbols;
c) repeating step b) at the arrival of subsequent packet data symbols.

30 In yet another form the present invention provides a method, apparatus and system of communicating by estimating time varying channel impairments in a multiple access packet based communication network, where channel

impairments comprise channel variation, signal frequency offset and signal time offset, comprising:

- a) initializing a set of channel impairment estimates based on initial pilot and preamble symbols included in a received packet;
- 5 b) performing a decoder operation which comprises processing the set of channel impairment estimates and the received packet to determine a set of transmit symbol estimates;
- c) updating the set of channel impairment estimates with the determined set of symbol estimates and received packet;
- 10 d) repeating steps b) and c).

In still another form the present invention provides a method, apparatus and system of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, comprising:

- a) estimating a frequency offset based on information included in a
15 received packet preamble;
- b) correcting a received signal using the estimated frequency offset;
- c) determining a channel estimate using information included in the received packet preamble;
- d) transforming a sample sequence of the received signal into the
20 frequency domain such that the sample sequence includes OFDM symbols and intervening cyclic prefixes;
- e) performing a decoding operation which comprises processing the determined channel estimate and received packet;
- f) generating a transmission sample sequence using the decoding
25 results and information in the received packet preamble;
- g) transforming the transmission sample sequence into the frequency domain;
- h) updating the determined channel estimate by combining the received sample sequence and the transmission sample sequence in the
30 frequency domain;
- i) repeating steps e) to h).

In a preferred embodiment, the combining operation of step h), which updates the determined channel estimate, is performed by dividing the received

sample sequence and the transmission sample sequence in the frequency domain.

In a further form the present invention provides a method, apparatus and system of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, where the receiver
5 retrieves OFDM symbols from a received signal and transforms the retrieved symbols to the frequency domain, comprising:

a) determine a matrix of training symbols comprised of symbol estimates derived from a decoder;

10 b) determine a matrix of frequency domain received OFDM symbols;

c) determine an intermediate channel estimate matrix by multiplying the OFDM symbol matrix by the conjugate of the training symbol matrix;

d) determine an intermediate matrix of training weights comprising the absolute value of the training symbol matrix;

15 e) perform a smoothing operation on both intermediate matrices comprising 2 dimensional filtering;

f) determine the channel estimate by dividing the smoothed channel estimate matrix with the smoothed training weight matrix.

In embodiments of the invention, the step d) determining an intermediate
20 matrix of training weights may comprise other functions such as, for example, (absolute value of the training symbol matrix)².

In still another form the present invention provides a method, apparatus and system of communicating in a multiple access network by estimating offsets in a receiver for receiving transmitted packets, comprising:

25 a) determine a matrix of received OFDM symbols;

b) determine a matrix of conjugated data symbols wherein the data symbols comprise one or more of preamble, training and estimated symbols;

c) determine a 2 dimensional Fourier transform matrix comprised of the received symbol matrix multiplied with the conjugated symbol matrix;

30 d) filter the Fourier transform matrix;

e) determine time and frequency offsets by locating peak power occurrences within the filtered Fourier transform.

In a particular embodiment, the above steps a) to e) for estimating offsets may be used effectively as a means of channel estimation. For example, in the above described form of the invention which provides communication by estimating time varying channel impairments, the step c) of updating the set of
5 channel impairment estimates with the determined set of symbol estimates and received packet may comprise the above steps a) to e) for estimating offsets.

In a further embodiment, the above method may be used as the channel estimator as required herein, in as much as updating the set of channel estimates with the determined set of symbol estimates.

10 In yet a further form the present invention provides a method, apparatus and system of communicating in a multiple access packet communication network by synchronizing a received signal in a multi antenna receiver comprising:

correlating a received signal observation at each of a plurality of antennae
15 with a known signal preamble to provide a received signal sequence;
determine a power signal of each received signal sequence;
combine the determined power signals in accordance with a time averaged weighting based on estimated antenna signal strength for each antenna;
determine a time of arrival for the received signal in accordance with a
20 predetermined threshold condition.

In embodiments of the present invention there is provided a computer program product comprising:

a computer usable medium having computer readable program code and computer readable system code embodied on said medium for communicating in
25 a multiple access communication network, said computer program product comprising:

computer readable code within said computer usable medium for performing the method steps as disclosed herein.

30 Other aspects and preferred aspects are disclosed in the specification and/or defined in the appended claims, forming a part of the description of the invention.

The present invention provides an improved or enhanced wireless link between two communicating devices, for example, an IEEE 802.11a Access

Point to an IEEE 802.11a Station or between two nodes in a wireless mesh. The present invention leads to enhanced key performance indicators for point to point links, namely, range, power, data rate and reliability. This is achieved by advanced signal processing techniques in the following areas to improve performance

- Decoding
- Synchronisation
- Equalisation
- Channel Estimation
- 10 - Full Exploitation of Multiple Receiver Antennae.

As would be understood by the person skilled in the art, in addition, techniques that exploit multiple antennas for transmission may be employed to provide electronically generated directional antennas in an adaptive manner. The following advantages stem from the present invention.

- 15 - Spatial rejection of interference,
- Significantly increased receiver sensitivity,
- Significantly increased robustness to fading, and
- Self configuration of antenna patterns

Spatial rejection of interference effectively ignores or rejects signals that are not emanating from the same location as the current or point of interest source. Rejecting these signals increases the probability that a signal may be received without errors thus increasing the reliability of the link and therefore the throughput to lower retransmissions and dropped packets. Interferers have a spatial signature as measured at the receive antenna that is substantially determined by their position. However, it is possible that transmitters that are not collocated could produce a similar spatial signature and it is also possible that collocated transmitters could produce different spatial signatures.

Significantly, increasing the receiver sensitivity means that the receiver may operate a lower SNR (Signal-to-Noise-Ratio) point which produces many benefits. Since the received power at which the signal may be successfully decoded has been reduced, the path loss may be increased by increasing the distance between the receiver and transmitter thereby increasing the range. Alternatively, the present invention allows the transmit power to be decreased

and still a link may be maintained. Increasing the receiver sensitivity also means that less power is required per bit and accordingly, it may be possible to transmit a higher number of information bits per constellation symbol. This increases the data rate.

5 Robustness to fading provided by the inventive techniques disclosed herein may decrease the amount of packet errors due to extreme radio channel variations or fades. By increasing robustness, a more reliable link may be created ensuring a better user experience and increased throughput through less re-transmissions and fewer dropped packets.

10 The use of multiple antennas for transmit and receive functions allows the rejection of interference from outside the direction of interest. This functionality is adaptive so no hands-on antenna orientation is required at install-time or during the life of the installations.

15 By way of example, indicative performance measures of a sample communications link are given with and without the use of the Point-to-Point technology of the present invention.

	Typical of Related Art	Present Invention
Range	300m	1km
Required T _x Power	1.0W	0.1W
Maximum Data Rate	500Kbps	5Mbps

20 The present invention also provides improved channel tracking capabilities. Channel tracking technology refers to the adaptation of the receiver, when the channel changes rapidly over the duration of a single packet. Typically, the channel estimate that is used to decode a received packet is determined from known sequences at the start of a packet. This estimate may be used to decode the whole packet. However, if the relative speed between the transmitter and receiver is great enough, the channel experienced at the beginning of the packet is substantially different from that at the end of a packet rendering the channel estimate incorrect for the end of the packet resulting in decoding errors. There are
25 other processes that manifest themselves as the radio channel changing over the packet. These include mismatches between the Transmit and Receive Radio processing resulting in residual frequency offsets and misalignments in the time

and frequency synchronisation. It is difficult to build transmit and receive radio devices that match perfectly.

The advanced signal processing techniques of the present invention allows a receiver circuit to build a progressive Channel Estimate that tracks the changes in the channel over the duration of a packet. The benefit of applying such Channel Tracking technology is the ability to communicate under high mobility conditions and under larger mismatches between the transmit and receive radio processing. By way of example, typical performance measures of a sample communications link are given with and without the use of the Channel Tracking technology.

	Typical of Related Art	Present Invention
Maximum Mobility	40 km/hr	400 km/hr

The present invention also provides interference cancelling allowing the removal of same standard interference from a signal. The term "same standard" refers to transmissions of similar packet structures from other users in a multiuser system, or multipath transmissions (reflections) from the same transmitter, or multiple transmit antenna in the case of a device equipped with multiple transmit antenna. In all wireless communications systems, multiple active transmitters share the wireless medium. This sharing may be done in a coordinated attempt in infrastructure networks by dividing the wireless medium into time and frequency slots or in an uncoordinated attempt in an-hoc networks by all active transmitters contesting for the right to use the medium. Both schemes limit the use of the medium to a well defined frequency and time where only one user may transmit. Packet collisions occur when two transmitters inadvertently choose to use the same frequency at the same time. The Interference Cancelling technology includes advance signal processing techniques that benefit the following areas

- Acquisition
- Interference Mitigation
- Range
- Network Throughput
- Reduced Control Overhead

Further benefits of the Interference Cancellation technologies of the present invention resolve collisions between two or more transmitters from the same standard transmitting at the same time on the same frequency. This has numerous advantages. Firstly, when collisions occur, all transmitted packets are
 5 received correctly increasing throughput and reliability by decreasing retransmissions and dropping packets. Secondly, by removing the requirement that only one transmitter may use a given frequency at a given time the amount of traffic that can be carried on the medium may be increased. Moreover, this may give greater flexibility in infrastructure design such as frequency planning and in
 10 the case of co-located competing networks such as two IEEE 802.11 networks from separate companies in adjoining offices.

In the case where the desired user and interfering users transmit according to different standards, the interference cancellation structure may employ a receiver and re-transmitter for all relevant standards. The receiver is then able to
 15 create hypotheses of the interfering signals thereby enabling interference cancellation.

Collisions may be resolved in the Physical Layer in accordance with embodiments of the present invention. The resulting reduction in network signaling overhead multiplies the benefits over and above the resolution of the
 20 two colliding packets. Typical quantitative measures are a doubling of network throughput and several orders of magnitude reduction in packet loss rate as follows:

	Typical of Related Art	Present Invention
Throughput	10 Mbps	20 Mbps

The multi-hop technology of embodiments of the present invention allows selected (and possibly all) wireless devices to act as routers, forwarding packets
 25 from one device to another in a communication network. This means that though two devices may not receive each others signals, if there is a set of intermediate devices that may be linked to form a radio path between them, then they may communicate to each other by passing their message through that intermediate set.

Depending on the particular network dynamics, the multi-hop technology may employ dynamic route determination techniques to build and maintain the required routing tables. Multi-hop networks provide many benefits in terms of flexibility, reliability and cost of infrastructure.

5 Flexibility is achieved through a self forming network that requires minimal planning. The only requirement is that no device may be isolated, in a radio range sense, from the core network. All configurations meeting this criterion may be possible.

10 If multiple paths between devices exist in the network, dynamic route determination may select a new route when the current route is blocked or congestion is best avoided. Therefore if a device was to go offline, the network may rearrange its routing tables to exclude that device from all routes and find a new path through the network thus creating a robust, self healing (and therefore more reliable network). Dynamic route determination continuously adapts to
15 network configuration changes allowing for mobile network nodes.

Multi-hop networks in accordance with embodiments of the present invention offer a simple solution to provide a high bandwidth link over a wide area. Due to easy flexible installations, low infrastructure costs and a high rate, reliable link, multi-hop networks generally offer excellent return on investment.

20 Four areas of application in the communications field which best utilize the benefits of the technologies of embodiments of the present invention have been identified by the inventor as

- Mobile Multi-hop Radio Networks
- Fixed Multi-hop Radio Networks
- 25 - IEEE 802.11a Access Point Chipsets
- 802.16 Base Stations
- OFDM Baseband Receiver Co-processor

The following describes each of the above identified applications in turn. Other applications may also benefit from these technologies of embodiments of
30 the present invention.

Firstly, a Mobile Multi-hop Radio Network requires effective real-time communication to networks of moving entities. This concept provides cost-effective bi-directional high bandwidth communication both between the mobile

entities and between fixed networks and the mobile entities. Wireless Routers are placed where service is required with regular connections to a wideband backbone network. A fixed network may be used to connect to other networks such as the internet or other private networks. Other than access to power and a physical mounting point no other infrastructure is required for each wireless router. The wireless routers may be fixed or mobile. The routers adapt to their environment in terms of link quality using, for example, data communications methods as would be understood by the person skilled in the art. Embodiments of the present invention provide a competitive advantage relative to other Multi-hop Radio Networks in that the improved mobility and range, as noted above, leading to a more efficient network is provided. Relative to related art Private Communications Networks, embodiments of the present invention provide significant improvements in Data Rate, Range, Mobility and cost of Network as noted above.

Secondly, a Fixed Multi-hop Radio Networks is provided by installing Wireless Routers at fixed user locations with links available to one or more wideband backbone connections. The only requirement is that all routers must be able to form a link (direct or hopped) back to a backbone connection. There is no need for expensive base station configurations and ultimate range is not limited by signal strength. The Fixed Multi-hop radio Network forms a flexible, low infrastructure cost solution in providing a high bandwidth connection to a Wide Area Network that is reliable, easily managed and self healing.

Furthermore, the present invention enables all decoder outcomes to be employed (decoder outcomes are stored across all iterations and able to be combined) in the receiver filter structure providing improved estimate determination. The number of users that may be supported is greatly increased. Particularly advantageous, for example, in OFDM systems the present invention does not require prohibitively large matrices to be inverted in forming estimates. Receiver performance is superior to that of the related art due to the quality of the feedback symbol provided by including decoding in the iteration loop. Embodiments of the present invention are based on interference cancellation where previous estimates of the multi user received signals are subtracted from the received signal to cancel the interference they cause. Accordingly, these

embodiments do not suffer the disadvantages and complexities of using tree search methodologies for multiuser signals which would necessitate exploring many paths through a given tree. The present invention advantageously enables decoding of each user's signal according to their Forward Error Correction
5 encoding. This use of strong error control code structure provides for significantly improved symbol estimates, resulting in superior interference estimates. This in turn allows support for significantly higher numbers of users. Embodiments of the present invention do not require synchronised users to enable improved multi user reception. Embodiments of the present invention advantageously use
10 decoder outcomes as training symbols rather than only using demodulator outcomes. Advantageously, receiver coefficients for beamforming may be determined without transmitter interaction. Also the use of decoder outcomes to improve channel estimates allows accurate estimation of the required beamforming coefficients. In accordance with embodiments of the present
15 invention, smoothing of channel estimate taps is performed in the frequency domain as well as the time domain. Further to this, embodiments of the present invention allow decoding of symbols more than once as a channel estimate corresponding to its interval is improved resulting in increased receiver sensitivity.

Further scope of applicability of the present invention will become apparent
20 from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

25 BRIEF DESCRIPTION OF THE DRAWINGS

Further disclosure, improvements, advantages, features and aspects of the present invention may be better understood by those skilled in the relevant art by reference to the following description of preferred embodiments taken in conjunction with the accompanying drawings, which are given by way of
30 illustration only, and thus are not limiting to the scope of the present invention, and in which:

Figure 1 illustrates a related art multiple access wireless communication system;

Figure 2 illustrates an example of a MAC failure in a related wireless communication system involving an access collision;

Figure 3 depicts self interference in WLAN network of a related art wireless communication system;

5 Figure 4 depicts a generic iterative receiver structure in accordance with a first embodiment;

Figure 5 depicts the transmission system model for coded CDMA;

Figure 6 depicts a canonical iterative multiuser decoder;

10 Figure 7 depicts an iterative multiuser decoder with linear multiuser estimation in accordance with a first embodiment;

Figure 8 depicts the recursive filter $\Lambda_x^{(n)}$ in accordance with a first embodiment for $n = 1$ the input signal is r while for $n \geq 2$ the input signal is $\hat{x}_k^{(n-1)}$; and

15 Figure 9 depicts Bit Error Rate versus users after 10 iterations, $N=8$, $E_b / N_0 = 5$ dB in accordance with a first embodiment;

Figure 10 shows a typical related art single pass OFDM receiver high level structure;

20 Figure 11 illustrates an adaptation of the single pass OFDM receiver high level structure of figure 10 in accordance with a second embodiment to facilitate iterative receiver technologies;

Figure 12 shows a OFDM Soft/Hard Decode and Re-transmit structure for use in Iterative Receive structure in accordance with a second embodiment;

Figure 13 shows a Hybrid Re-transmit in accordance with a second embodiment;

25 Figure 14 shows a Hard Decode and Re-Modulate for OFDM Soft/Hard Decode and Re-transmit structure in accordance with a second embodiment;

Figure 15 shows a Soft Decode and Re-Modulate for OFDM Soft/Hard Decode and Re-transmit structure in accordance with a second embodiment;

30 Figure 16 shows a structure for time domain channel application process in accordance with a second embodiment;

Figure 17 shows a structure for frequency domain channel application process in accordance with a second embodiment; and

Figure 18 shows an Example of a Typical OFDM Packet Physical layer Format and an associated Multiplexer mapping;

5 Figures 19a and 19b show a wireless modem incorporating a baseband receiver processor in accordance with preferred embodiments of the present invention;

Figure 20 illustrates a packet structure in accordance with related art;

Figure 21 illustrates an example related art time synchronisation decision;

Figure 22 shows triangle filter coefficients for a receiver filter in accordance with a third embodiment of the invention;

10 Figure 23 shows an example of a filtered decision statistic in accordance with a third embodiment of the invention;

Figure 24 represents an actual frequency domain of a related art radio channel;

15 Figure 25 represents the frequency domain of figure 24 after receiver phase and frequency offset correction;

Figure 26 represents an error pattern for a related art processing of a receiver;

Figure 27 represents a radio channel estimate after smoothing across OFDM symbols in accordance with a fourth embodiment of the invention;

20 Figure 28 represents an error pattern for a fourth embodiment of the invention using perfect training symbols;

Figure 29 represents a raw radio channel estimate or channel estimate database in accordance with a fourth embodiment of the invention;

25 Figure 30 is an example of a WLAN packet format in accordance with related art;

Figure 31 is an OFDM symbol sub-carrier matrix structure in accordance with a fifth embodiment of the invention;

30 Figure 32 is a representation of channel power (amplitude) over a sub-carrier and OFDM symbol resulting from application of a fifth embodiment of the invention;

Figure 33 is a representation of channel phase corresponding to the waveform represented in figure 32;

Figure 34 is a representation of a synchronisation metric of a sub-carrier and OFDM symbol in accordance with a fifth embodiment of the invention.

DETAILED DESCRIPTION

System Overview

5 In wireless networks a signal received at a network device comprises components from all active transmitters. These components, along with noise, add together resulting in the received signal. In some cases, only one of these components, corresponding to a specific transmitter, is of interest. In other cases, such as a reception at a network access point, several of the received
10 components are of interest. In either case the presence of the other signal components in the received signal inhibits the accurate estimation of any given transmitted signal of interest. In accordance with embodiments of the present invention a system and methods and apparatus for processing a received signal comprising one or more received signal components from different transmitters is
15 disclosed herein. The processing typically resides in the baseband receiver processing of a wireless transceiver 190 as illustrated in figures 19a and 19b. The Radio Frequency Transceiver Integrated Circuit (IC) is an analogue device that interfaces between the digital signal processing components LLC, MAC, Rx, Tx, and the antenna system of the transceiver. In receive mode IC amplifies and
20 downconverts the received signal suitable for driving analogue to digital converters. In transmit mode it up converts and amplifies the signal for excitation of the antenna.

The baseband receiver is responsible for determining the existence of any packets and then to recover transmitted information estimates from the received
25 signal if packet(s) are deemed to exist.

A canonical baseband receiver processor Rx is shown in figure 19b. The received signals for each antenna are supplied as input by the Radio Frequency Circuit IC. These signals are then filtered 302 by filters 302a, 302b to remove any out of band interference. The filtered signals 303 are then combined with the
30 current Received Signal Estimates 306, implementing an interference cancellation function 304. Ideally, the interference cancellation module 304 removes the signal components in the received signal pertaining to all packets

except for the packet of interest. The packet of interest is then decoded by feeding the Interference Cancelled output 309 to a Single Packet Processor 313.

The Single Packet Processor 313 takes a Multiantenna received signal as delivered by the Interference Cancellation module 304 and produces an estimate of the transmitted information bits 314 and an estimate of the received symbols 306 for the packet of interest. These symbols, along with the channel estimates for the packet of interest, are then fed back to the interference cancellation module 304. In some cases it is preferred to send back only the transmitted symbol estimates to the interference cancellation module 304.

The Single Packet Processor 313 may contain advanced or conventional single packet techniques. The multiuser interference rejection performance of the receiver will be better if the Single Packet Processor is of high quality. Techniques pertaining to synchronisation and channel estimation are key to the performance of the Single Packet Processor 313.

Techniques that improve the robustness of the synchronisation and channel estimation employed in decoder 310 are described herein. The synchronisation uses all antenna signals in its operation. The channel estimation makes use of the decoder outcomes to improve the channel estimation accuracy.

New packets are found by a searcher in the interference cancellation module 304. The searcher investigates an intermediate signal generated in the module 304. This intermediate signal is the received signal minus the estimated received signal for all currently detected packets and is referred to as a noise hypothesis since in ideal conditions all transmitter components are removed from the received signal leaving behind only the random noise.

In applications sensitive to latency the feedback loops, both inside 310 for decoder outcome assisted channel estimation, and between 304, 310 and 312 for multi packet interference cancellation may be executed at a rate higher than the packet rate. In OFDM based systems the preferred choice for the loop rates is the OFDM symbol rate with decoding and interference cancellation occurring at the OFDM symbol rate.

In applications where packet based decoding and interference cancellation may be performed at the packet rate additional packet-based techniques for the

Single Packet Processor 313 are disclosed. These techniques leverage the extra signal processing gain available when considering long sequences of symbols.

In either case, lists of current estimates of the quantities passed between the Interference Canceller 304 and the Single Packet Processor 313 are required.

5 A controller determining which packet is to be updated may also be utilised.

With reference to figures 4 to 9, a first embodiment stems from the general realization that over a number of iterations using linear filters in a multiuser receiver, each iteration provides new information and, as the filter structure converges, the output of the decoders also converges and eventually becomes
10 completely correlated. The linear filters of the multiuser decoding circuit means may be structured in accordance with at least one predetermined recursive expression.

An innovation in the filter design of a first embodiment disclosed herein is to exploit the fact that information provided by the decoders is initially only
15 marginally correlated over iterations, i.e. in the first few iterations, each iteration provides new information. As the structure converges, the output of the decoders also converges and eventually becomes completely correlated.

The disclosed filter design is based on a technique to use all available information from all previous iterations. This implies that the filter grows linearly
20 in size by a factor equal to the number of users. This is clearly impractical. Thus, the disclosed filter design makes it possible to use all the available information through recursive feedback of the filter output over iterations, without requiring a growing filter. The size of the filter remains the same. In order to achieve this, the filters in the structure may be designed according to the recursive expressions
25 derived herein.

Related structures, having lower complexity implementations, are obtained by modifying the specific filters used in the structure. The general recursive structure, however, is still fundamental for such modified filters. In these cases, the individual filters are designed according to appropriately different strategies
30 using the principles disclosed herein.

The recursive filtering structure for iterative signal processing disclosed herein is not limited to multiuser detection, but may also be directly applied within systems and functionalities of the same structure. Examples of such applications

are iterative equalisation, iterative joint channel estimation and detection/decoding, iterative space-time processing, and iterative demodulation.

In a broad aspect of the first embodiment, an iterative signal processing arrangement shown generally in figure 3 as 10 having one or more pairs of first and second signal processing components 1, 2, the pairs of components being in iterative configuration, each of the first signal processing components having as input one or more received signals dependent upon one or more transmitted signals, wherein for each said signal processing component pair the output of said first signal processing component 1 is an estimate of a characteristic of a selected transmitted signal based on the current and one or more previous signals received by said first signal processing component 1, which is input to said corresponding second signal processing component 2 that provides a further estimate of said selected transmitted signal to the output of said second signal processing component 2, the outputs of all said second signal processing components of respective pairs are input to each said first signal processing components of all said pairs in a succeeding iteration cycle.

In a further aspect of the first embodiment, the iterative signal processing arrangement 10 according to that described above wherein said first signal processing component 1 comprises at least two linear iterative filters wherein a first of said linear iterative filters outputs an estimate of a selected characteristic of a selected one or said transmitted signals to said second signal processing component 2, and a second of said iterative filters having the same inputs as said first linear iterative filter provides an estimate of a characteristic of a selected of one or more transmitted signals and then delays by one iteration cycle said estimate and outputs said delayed estimate to an input of said first linear iterative filter.

This first embodiment is intended for application to any communication system described by a generic linear channel model. The received signal at the input to the receiver is described by a weighted sum of the transmitted signals plus noise. The set of weighting factors represents a set of linear constraints imposed on the transmitted signals. Other constraints could possibly have been imposed on the signals. These other constraints are independent of the linear constraints imposed by the linear channel.

The optimal receiver structure finds the estimates of the transmitted signals, subject to all the imposed constraints. This approach is prohibitively complex for most practical cases of interest. As an alternative, a generic iterative receiver structure comprises of two separate components (see Figure 4). The first component 1 finds the optimal estimates, only subject to the linear channel constraints, ignoring all other constraints. Only preferably these estimates are shuffled by reordering according to a pre-determined order (de-interleaved) and used as inputs to the second component 2 which finds the optimal estimates subject only to all the other constraints, ignoring the linear channel constraints. These estimates are in turn, preferably shuffled back into the original order (interleaved), undoing the pre-determined reordering, and used as inputs to the first component 1 in the succeeding iteration cycle.

The optimal design of the first component 1, enforcing the linear channel constraints is often also prohibitively complex. To limit complexity, the component design itself can be constrained to be linear, leading to a linear signal processing component. The design of this linear signal processing component, given selected inputs, is the main subject of this disclosure with respect to the first embodiment. For the following description, the first embodiment lies in the linear signal processing component, or signal processing component 1, corresponding to component 1 in Figure 4. The remaining part of Figure 4 is referred to as signal processing component 2.

The function of the linear signal processing component 1 is to separate a selected transmitted signal from other "interfering" transmitted signals, based on the received signal which is a weighted sum of all transmitted signal as described above.

The input to the linear signal processing component 1 are one or more received signals and one or more estimates of the transmitted signals, provided by signal processing component 2. The output of the linear signal processing component 1 is an estimate of the selected transmitted signal.

The linear signal processing component 1 comprises two linear filters. The first filter provides as output estimates of the selected transmitted signal based on inputs of one or more of the input signals to the linear signal processing component, the output of this first filter delayed by one processing time period of

the iterative cycle, and the output of the second filter delayed by one processing time period of the iterative cycle.

The second filter provides as output estimates of one or more of the other transmitted signals (interfering with the selected transmitted signal) based on
5 inputs of one or more of the input signals to the linear signal processing component, and the output of the second filter delayed by one processing time period of the iterative cycle.

The output of the first filter is the output of the linear signal processing component.

10 Specific embodiments of the first embodiment will now be described in some further detail with reference to and as illustrated in the accompanying figures. These embodiments are illustrative, and not meant to be restrictive of the scope of the embodiment. Suggestions and descriptions of other embodiments may be included but they may not be illustrated in the accompanying figures or
15 alternatively features of the embodiment may be shown in the figures but not described in the specification.

This embodiment is described using linear multiuser estimators (MUEs) suitable for use as part of an iterative multiuser decoder. A specific application of the technique in the field of turbo-decoding in a transmission system for coded
20 CDMA is provided. However, as stated previously the structure of the filter and the principles revealed are useful in many other areas of the communications field. Thus the embodiment provided should not be considered as limiting in any way.

The specification includes theoretical considerations expressed in an
25 appropriately precise fashion and uses mathematical analysis to prove the correctness of the approach using assumptions as required. Not all proofs of theorems used are provided herein. A disclosure such as that contained herein has directed correlation to practical devices and configurations of filter elements of performing the functions described. Furthermore the disclosure provided
30 herein would be readily understood by those skilled in the art. The disclosure is such that a person skilled in the art can readily translate the theoretical configurations of elements disclosed herein into a variety of devices to solve problems or improve the performance of devices and algorithm in a variety of

application areas some of which have been described previously and that will be described herein.

This embodiment is intended for application to any communication system described by a generic linear channel model. The received signal at the input to the receiver is described by a weighted sum of the transmitted signals plus noise.
5 There could be multiple received observables pertaining to the same symbol interval, ie, the received signal can be a vector of received observables,

$$\mathbf{r} = \sum_{i=1}^K s_i x_i + \mathbf{n} \quad (1)$$

where a total K signals are transmitted, s_k is the weighting factors for signal
10 x_k and \mathbf{n} is a noise vector.

Here, the set of weighting factors, s_1, s_2, \dots, s_K represents a set of linear constraints imposed on the transmitted signals. Other constraints could possibly have been imposed on the signals x_1, x_2, \dots, x_K such as error control encoding, channel fading etc. These other constraints are independent from the linear
15 constraints imposed by the linear channel.

The optimal receiver structure finds the estimates of the transmitted signals, subject to all the imposed constraints. This approach is prohibitively complex for most practical cases of interest. As an alternative, a generic iterative receiver structure comprises of two separate components (see Figure 4). The
20 first component 1 finds the optimal estimates, only subject to the linear channel constraints, ignoring all other constraints. These estimates are inputs to the second component 2 which finds the optimal estimates subject only to all the other constraints, ignoring the linear channel constraints. These estimates are in turn, provided as inputs to the first component 1 in the following iteration cycle.

25 The optimal design of the first component 1, enforcing the linear channel constraints is often also prohibitively complex. To limit complexity, the component 1 design itself can be constrained to be linear, leading to a linear filter. The design of this linear filter, given selected inputs to the filter, is disclosed herein. The function of the filter is to separate a selected signal from other
30 "interfering" signals, based on the received signal which is a weighted sum of all transmitted signal as described in (1). All the references provided in this

specification are incorporated herein by reference and for all purposes. An innovation in the filter design disclosed herein is to exploit the fact that information provided by the decoders is initially only marginally correlated over iterations, i.e., in the first few iterations, each iteration provides new information. The disclosed
5 filter design is based on a technique to use all available information from all previous iterations.

This implies that the filter grows linearly in size by a factor equal to the number of users. This is clearly impractical. Thus, the disclosed filter design makes it possible to use all the available information through recursive feedback
10 of the filter output over iterations, without requiring a growing filter. The size of the filter remains the same. The filter design is based on two linear iterative filters, where the first linear filter provides an estimate of the desired signal based on the received signal, the most current estimates of all user signals from signal processing component 2, and the output of the second linear filter which is a
15 vector of estimates of all user signals based on all previous inputs to signal processing component 1. The two linear filters are shown explicitly in Figure 8.

The linear iterative filters may appropriately be designed based on the linear minimum mean squared error criterion, according to the recursive expressions derived therein.

20 This embodiment applies to any system described by such a generic linear channel model, and where an iterative receiver as described above, is to be applied. Examples of such applications include (but are not limited to) the following:

- Decoding of coded transmission in a linear multiple access system.
- 25 • Decoding of coded transmission over an inter-symbol interference channel.
- Joint channel estimation and detection/decoding of coded transmission over unknown channels.
- Decoding of space-time coded transmission.
- 30 • Decoding of coded transmission with higher order modulation formats.

In the following, the design is demonstrated for multiuser decoding for a general linear multiple access system.

System Model in Multiuser Decoding Example

The basic principle behind turbo decoding is to decode independently with respect to the various constraints imposed on the received signal. The overall constraint is accommodated by iteratively passing extrinsic information between the individual decoders. For turbo codes, these constraints are the parallel concatenated codes. For turbo-equalisation they are the channel code and the memory of the inter-symbol interference channel. For multiuser decoding, there are constraints due to the multiple-access channel and due to the individual users' encoders.

In this embodiment, a theoretical framework for the derivation of linear multiuser estimators (MUEs) suitable for use as part of an iterative multiuser decoder is disclosed. We consider a two-input linear minimum mean squared error (LMMSE) estimator which inspires our main result, the derivation of a recursive Bayesian estimator. The proposed estimator yields estimates based on the received signal and all the successive outputs provided by the error control code decoders over all previous iterations. This approach is motivated by an observation that these estimates are loosely correlated during initial iterations.

Notation: P^n is the space of probability n -vectors (length n non-negative vectors that sum to 1). For random vectors \mathbf{x} and \mathbf{y} , $E[\mathbf{x}]$ is the expectation, $\text{var } \mathbf{x} = E[\mathbf{x}^* \mathbf{x}]$ and $\text{cov } \mathbf{x} = \langle \mathbf{x}, \mathbf{x} \rangle = E[\mathbf{x} \mathbf{x}^*]$. Likewise $\text{cov}(\mathbf{x}, \mathbf{y}) = \langle \mathbf{x}, \mathbf{y} \rangle = E[\mathbf{x} \mathbf{y}^*]$.

We consider the K -user linear multiple-access system of Figure 5. User $k, k=1,2,\dots,K$ encodes its binary information sequence $b_k[l]$ using a rate R code C , to produce the coded binary sequence $d_k[l]$.

Consider transmission of $2L$ code bits per user. Each user independently permutes their encoded sequence with an interleaver π_k . Denote the sequence output from the interleaver of user k as $u_k[l], l=1,2,\dots,2L$. Pairs of interleaved code bits $u_k[l]$ are memorylessly mapped onto the quaternary phase-shift keyed (QPSK) signal constellation, $\mathbf{Q} = \{\pm 1/\sqrt{2} \pm j/\sqrt{2}\}$, giving sequences of modulated code symbols $x_k[l]$, where $i=1,2,\dots,L$ is the symbol time index. We

choose QPSK only for simplicity and note that different code constraints and symbol maps across users are possible in general.

At symbol time i , each user transmits $s_k[i]x_k[i]$, the multiplication of $x_k[i]$ with the real N -chip spreading sequence, $s_k[i] \in \{-1,1\}^N$. We model the use of spreading sequences with period much longer than the data symbol duration by letting each element of $s_k[i]$ be independent and identical distributed over users and time. For conceptual ease only, users are symbol synchronised, transmit over an additive white Gaussian noise (AWGN) channel, and are received at the same power level. These assumptions however are not required. Write the chip-match filtered received vector $\mathbf{r}[i] \in \mathbb{C}^N$ at symbol time $i = 1, 2, \dots, L$ as

$$\mathbf{r}[i] = \mathbf{S}[i]\mathbf{x}[i] + \mathbf{n}[i] \quad (2)$$

where $\mathbf{S}[i] = (s_1[i], s_2[i], \dots, s_K[i])$, is a $N \times K$ matrix with the spreading sequence for user k as column k . The symbol \mathbb{C} represents the set of complex numbers. The vector $\mathbf{x}[i] \in \mathcal{Q}^K$ has elements $x_k[i]$ and the vector $\mathbf{n}[i] \in \mathbb{C}^N$ is a sampled circularly symmetric i.i.d. Gaussian noise process, with $\text{cov} \mathbf{n}[i] = \sigma^2 \mathbf{I}$. The symbol \mathcal{Q} represents the set of possible modulated symbols, e.g. QPSK.

Henceforth, it is not required to identify specific symbol intervals and these indices will be omitted. For later use, we define $\mathbf{S}_{\bar{k}} = (s_1, s_2, \dots, s_{k-1}, s_{k+1}, \dots, s_K)$ and $\mathbf{x}_{\bar{k}} = (x_1, x_2, \dots, x_{k-1}, x_{k+1}, \dots, x_K)$ to indicate deletion of user k from \mathbf{S} or \mathbf{x} .

20 Recursive Filter from Multiuser Estimation

Application of the turbo-principle to the coded linear multiple-access system, where for each user, we treat the error control code as one constraint and the multiuser channel (2) as the other constraint, results in the canonical receiver structure of Figure 6[1].

25 An iteration n_1 , the multiuser APP takes an input \mathbf{r} and the set of extrinsic probabilities $\mathbf{q}_k^{(n-1)}$ from user $k = 1, 2, \dots, K$ calculated in the previous iteration $n - 1$. $\mathbf{q}_k^{(n-1)}[i] \in \mathcal{P}^{\mathcal{Q}}$ is the extrinsic probability distribution on the transmitted symbols $x_k[i] \in \mathcal{Q}$ of user k . The set \mathcal{Q} is the set of all possible modulated symbols at the transmitter. The multiuser APP calculates the updated extrinsic probability vector

$\mathbf{p}_k^{(n)}[i]$ for user k . After appropriate de-interleaving, the extrinsics $\mathbf{p}_k^{(n)}$ are used as priors for independent APP decoding of the code C by each user, producing (after interleaving) the extrinsics $\mathbf{q}_k^{(n)}$ which serve as priors for the subsequent iteration. The marginalisation in the multiuser APP requires summation over 5 $|\mathcal{Q}|^{K-1}$ terms. Many lower-complexity alternatives have been proposed while retaining the same basic architecture.

Consider the receiver structure shown in Figure 7. There is a bank of linear filters $\Lambda_k^{(n)}$, one for each user. The coefficients of these filter may be re-computed every iteration. For the first iteration, $n=1$, the input to $\Lambda_k^{(1)}$ is just \mathbf{r} .
 10 For subsequent iterations $n=2,3,\dots$, the input to the filter for user k is \mathbf{r} and a set of signal estimates for all the other users from previous iterations, $\{\hat{x}_k^{(m)} : k' \neq k, m \in M\}$, where $M \subseteq \{1,2,\dots,n-1\}$ is a set defining the memory order of the iteration. Typically in the literature, $M = \{n-1\}$, although recently $M = \{n-1, n-2\}$ has been considered [2].

15 The output of the filter $\Lambda_k^{(n)}$ is an updated sequence of estimates $\hat{x}_k^{(n)}$ of the corresponding code symbol for user k . These estimates are mapped from the signal space onto the probability vector space using a symbol-wise mapping $T: \mathcal{Q} \rightarrow P^{|\mathcal{Q}|}$. The resulting sequence of probability vectors $\mathbf{p}_k^{(n)}$ are used as priors for individual APP decoding of the code C . These APP decoders can output
 20 either posterior or extrinsic probabilities $\mathbf{q}_k^{(n)}$ (both approaches have been investigated in the literature). The sequence of probability vectors $\mathbf{q}_k^{(n)}$ is in turn mapped back onto the signal space by a symbol-wise function $U: P^{|\mathcal{Q}|} \rightarrow \mathcal{Q}$. Typically, T calculates the vectors $\mathbf{p}_k^{(n)}$ assuming that $\hat{x}_k^{(n)}$ is Gaussian distributed with known mean and variance, $\hat{x}_k^{(n)}: N(\tilde{\mu}_k^{(n)}, \tilde{\zeta}_k^{(n)})$. Likewise, a common choice
 25 for U is the conditional mean.

The following easily proved lemma provides a useful general framework for the derivation of filters $\Lambda_k^{(n)}$.

Lemma 1

Suppose that for a parameter x we have the vector observation $c = (a'b')'$, the concatenation of two vector observations a and b . The LSE estimate of x

$$\tilde{x} = \langle x, a \rangle \langle a, a \rangle^{-1} a + m (b - \langle b, a \rangle \langle a, a \rangle^{-1} a) \quad \text{given } c \text{ is} \quad (3)$$

where

$$m = (\langle x, b \rangle - \langle x, a \rangle \langle a, a \rangle^{-1} \langle a, b \rangle) (\langle b, b \rangle - \langle b, a \rangle \langle a, a \rangle^{-1} \langle a, b \rangle)^{-1}$$

10

We see that (3) can be written as $\tilde{x} = ga + m(Fa - b)$, where

$$m = (\langle x, b \rangle - \langle x, a \rangle \langle a, a \rangle^{-1} \langle a, b \rangle) (\langle b, b \rangle - \langle b, a \rangle \langle a, a \rangle^{-1} \langle a, b \rangle)^{-1} \quad (4)$$

$$F = \langle b, a \rangle \langle a, a \rangle^{-1}$$

(5)

15

$$g = \langle x, a \rangle \langle a, a \rangle^{-1}$$

(6)

20

So far in the literature, linear filters $\Lambda_k^{(n)}$ for multiuser estimation in iterative decoding have been designed based on the received signal r and the most current code symbol estimates of the interfering users $\hat{x}_k^{(n)}$. After n iterations, we have however a sequence of such estimates available, namely $\{\hat{x}_k^{(1)}, \hat{x}_k^{(2)}, \dots, \hat{x}_k^{(n)}\}$ together with r . It has been observed that the estimates are not strongly correlated during the initial iterations [2].

Consider the following recursively defined version of observables as input to the filter $\Lambda_k^{(n)}$,

25

$$c_k^{(n)} = \begin{cases} r & n = 1 \\ \begin{pmatrix} c_k^{(n-1)} \\ \hat{x}_k^{(n-1)} \end{pmatrix} & n = 2, 3, \dots \end{cases} \quad (7)$$

Direct application of the LMMSE criterion results in $\Lambda_k^{(n)} = \langle x_k, c_k^{(n)} \rangle \langle c_k^{(n)}, c_k^{(n)} \rangle^{-1}$. It is clear however that $\Lambda_k^{(n)}$ grows in dimension with n which is impractical.

Inspired by recursive Bayesian estimation (RBE) [3], we can prove the following theorem that solves this dimensionality problem by giving a recursive form from $\Lambda_k^{(n)}$ (subject to certain constraints on the input signal).

Theorem 1

5 Make the following assumptions,

A1: The received signal $r = Sx + n$, is described according to (2) where n is circularly symmetric complex Gaussian with $\text{cov}n = \sigma^2 I$, and σ^2 and s are known.

A2: The interleaved code symbol estimates of the interfering users $\hat{x}_k^{(n)}$ coming out of the single user APP decoders can be written as $\hat{x}_k^{(n)} = x_k^{(n)} + \hat{v}_k^{(n)}$ where $\hat{v}_k^{(n)}$ is uncorrelated with x and also uncorrelated over time and iterations, but not over users at a given iteration, i.e. $\langle x, \hat{v}_k^{(n)} \rangle = 0, \langle \hat{v}_k^{(n)}, \hat{v}_k^{(m)} \rangle = 0$ for $n \neq m$ and $\langle \hat{v}_k^{(n)}, \hat{v}_j^{(n)} \rangle = q_{kj}$.

Define $Q_k^{(n)} = \langle \hat{v}_k^{(n)}, \hat{v}_k^{(n)} \rangle$, with elements determined as shown above.

15 Let $c_k^{(n)}$ be according to (7). Under **A1** and **A2**, the LMMSE estimate of x_k given $c_k^{(n)}$ is given by the output $\tilde{x}_k^{(n)}$ of the recursive filter shown in Figure 8.

The update for the estimate is

$$\tilde{x}_k^{(n)} = \tilde{x}_k^{(n-1)} + m_k^{(n)} (\hat{x}_k^{(n-1)} - \tilde{x}_k^{(n-1)})$$

20

The filters in the figure are defined as follows:

$$m_k^{(n)} = -w_k^{(n)} (I + Q_k^{(n-1)} - W_k^{(n)})^{-1}$$

$$M_k^{(n)} = (I - W_k^{(n)}) (I + Q_k^{(n-1)} - W_k^{(n)})^{-1}$$

with the recursive update equations for $n = 3, 4, \dots$

25

$$w_k^{(n)} = w_k^{(n-1)} \left[I - (H_k^{(n-1)})^{-1} (I - W_k^{(n-1)}) \right]^{-1}$$

$$W_k^{(n)} = W_k^{(n-1)} + (I - W_k^{(n-1)}) (H_k^{(n-1)})^{-1} (I - W_k^{(n-1)})$$

$$H_k^{(n-1)} = I + Q_k^{(n-2)} - W_k^{(n-1)}$$

The initial conditions with $\tilde{\mathbf{x}}_k^{(0)} = 0$ and $\mathbf{x}_k^{(0)} = \mathbf{0}$ are $\mathbf{m}_k^{(1)} = \mathbf{s}_k^t (\mathbf{S}\mathbf{S}^t + \sigma^2 \mathbf{I})^{-1}$,
 $\mathbf{M}_k^{(1)} = \mathbf{S}_k^t (\mathbf{S}\mathbf{S}^t + \sigma^2 \mathbf{I})^{-1}$ for $n=1$ and $\mathbf{w}_k^{(2)} = \mathbf{s}_k^t (\mathbf{S}\mathbf{S}^t + \mathbf{I})^{-1} \mathbf{S}_k$, $\mathbf{W}_k^{(2)} = \mathbf{S}_k^t (\mathbf{S}\mathbf{S}^t + \sigma^2 \mathbf{I})^{-1} \mathbf{S}_k$
 for $n=2$.

Computer simulations have been used to evaluate the proposed
 5 technique. For the purposes of simulation, each user used the maximum free
 distance 4 state convolutional code naturally mapped onto QPSK. Each user is
 therefore transmitting 1 bit per channel use. Binary spreading sequences with
 $N=8$ were generated i.i.d. at each symbol for each user. Transmission is chip
 synchronous and all users are received at the same power level.

10 Indicative simulation results are shown in Figure 9. Three curves are
 shown. PIC is the parallel interference cancellation method of [4]. IPIC is the
 improved parallel interference cancellation of [2]. RBE is the proposed recursive
 Bayesian estimation technique. Each of the curves begins for small numbers of
 users at the single-user BER near 10^{-4} . As each receiver fails to converge, its
 15 curve deviates from single-user. For PIC, this occurs at $K/N=1.125$. For IPIC, the
 limit is 1.625 and for RBE 1.875. The performance benefit of IPIC over PIC is
 reported in [2]. The recursive Bayesian technique supports even higher loads. In
 fact, further numerical investigations (for smaller systems) have shown that RBE
 supports almost the same load as using the multiuser APP.

20 Described herein is a computationally efficient recursive filter for use in
 iterative multiuser decoding. This filter uses the entire history of outputs from the
 single user decoders in order to accelerate convergence and to support greater
 loads.

25 With reference to figures 10 to 18 a second embodiment is described
 where there are a number of specific solutions offered which fall out from the
 general solution of (or realization that) adapting related art single pass OFDM
 receivers to iteratively receive signals at the sampling level allows the receiver to
 differentiate a desired packet from an observation of an interference (collision)
 signal at the receiver input. These solutions are as follows:

- 30
- An overall system solution – Iterative Receiver Structure itself.
 - Additional solution aspect – Samples Estimates list.
 - Additional solution aspect – Information Bit Estimates list.

- Additional solution aspect – Multiplexing of Time/Frequency Domain Channel Application Sample Estimates.

In one aspect, the second embodiment provides a system and method of receiving OFDM packets comprising the following:

- 5 a) sample a receiver input signal consisting of signals from one or more antenna;
- b) add the input signal with one of a plurality of prior stored received packet sample estimates to determine a packet sample hypothesis;
- c) determine an information bit estimate from the sample hypothesis
10 for storage in an information bit estimates list;
- d) determine an updated received packet sample estimate from the sample hypothesis for updating the plurality of prior stored estimates;
- e) subtract the updated sample estimate from the sample hypothesis to determine a noise hypothesis and provide the noise hypothesis as the receiver
15 input signal;
- f) repeat steps a) to e) until at least one or more complete packets are accumulated in the information bit estimates list.

In another aspect, the second embodiment provides a system and method of providing a sample estimates list in an OFDM receiver comprising the
20 following:

- a) sample a receiver input signal;
- b) determine a packet sample estimate from the sampled receiver input signal;
- c) store the packet sample estimate;
- 25 d) determine a packet sample hypothesis by adding the receiver input with a selected previously stored packet sample estimate;
- e) determine an updated packet sample estimate by decoding and re-transmission modelling the packet sample hypothesis;
- f) update the selected previously stored packet sample estimate with
30 the updated packet sample estimate.

In yet another aspect the second embodiment provides a system and method of providing a packet information bit estimates list in an OFDM receiver comprising the following:

a) determine a packet sample hypothesis by adding a receiver input with a selected previously stored packet sample estimate;

b) determine an information bit estimate by decoding the packet sample hypothesis with one or more of a hard decoding technique and a soft decoding technique

c) storing the information bit estimate with one or more previously determined information bit estimates;

d) repeating steps a) to c) until a complete packet is accumulated.

In still another aspect, the second embodiment provides a system and method of determining a hybrid OFDM received packet sample estimate comprising the step of:

multiplexing a time domain channel application received sample estimate with a frequency domain channel application received sample estimate, such that the multiplexed time domain sample estimate is mapped to correspond to one or more of;

an OFDM signal cyclic prefix;

an OFDM tail portion, and;

an OFDM guard period,

wherein the multiplexed frequency domain sample estimate is mapped to correspond to one or more of;

an OFDM signal preamble and;

an OFDM payload data symbol.

In another aspect the second embodiment provides an iterative sample estimation method for OFDM packet based network communication comprising the following steps:

a) selecting either the windowed matched received samples or the noise hypothesis as the input signal;

b) adding an empty packet estimate to a samples estimate list containing packet sample estimates;

c) selecting one of said list entries;

d) adding said packet samples estimate to said input signal to create a packet received samples hypothesis;

e) decoding and re-transmission modelling of said packet received samples hypothesis to create a new packet received samples estimate and new information bit estimates;

5 f) updating said information bit estimate list with new information bit estimates;

g) subtracting said new packet samples estimate from said packet received samples hypothesis to create a noise hypothesis; and

h) updating said samples estimate list entry with said new packet samples estimate;

10 all said steps being iterated at least once for each packet.

In a further aspect the second embodiment provides an iterative sample estimation method according to the previous paragraph wherein step e) further comprises:

15 i) soft decoding said selected packet sample estimate to create soft encoded bits and new packet information bit estimates for reinsertion into said information bit estimates list;

j) soft modulating said soft encoded bits to create a transmitted symbol estimate;

20 k) constructing the time domain channel estimate from said packet received samples hypothesis and said transmitted symbol estimates;

l) constructing the packet transmit sample estimate from said transmitted symbol estimate;

25 m) convolving said time packet transmit sample estimate with said time domain channel estimate to create the time domain channel applied received samples estimate; and in parallel with steps k) and m);

n) constructing the frequency domain channel estimate from said packet received samples hypothesis and said transmitted symbol estimates;

o) multiplying said frequency domain channel estimate with said transmitted symbol estimates to create packet received symbol estimates; then

30 p) constructing the frequency domain channel applied received samples estimate from the packet received symbol estimates; and

q) multiplexing the time domain channel applied received samples estimate with the frequency domain channel applied received samples estimate

for reinsertion into said samples estimate list, wherein steps n) to p) are repeated for each OFDM symbol in a packet.

In still another aspect, the second embodiment provides an iterative sample estimation method according to the paragraph previous to the preceding paragraph wherein step e) further comprises:

5 r) hard decoding said selected packet sample estimate to create hard encoded bits and new packet information bit estimates for reinsertion into said information bit estimates list;

10 s) hard modulating said hard encoded bits to create a transmitted symbol estimate;

t) constructing the time domain channel estimate from said packet received samples hypothesis and said transmitted symbol estimates;

u) constructing the packet transmit sample estimate from said transmitted symbol estimate;

15 v) convolving said time packet transmit sample estimate with said time domain channel estimate to create the time domain channel applied received samples estimate; and in parallel with steps t) and u);

w) constructing the frequency domain channel estimate from said packet received samples hypothesis and said transmitted symbol estimates;

20 x) multiplying said frequency domain channel estimate with said transmitted symbol estimates to create packet received symbol estimates; then

y) constructing the frequency domain channel applied received samples estimate from the packet received symbol estimates; and

25 z) multiplexing the time domain channel applied received samples estimate for reinsertion into said list.

With reference to figures 10 to 18, the following blocks are used for receiver signal processing techniques in accordance with the second embodiment;

- OFDM Soft Output Decode 288
- 30 • OFDM Hard Output Decode 222
- Encode 224
- Soft Modulate 230

- Hard Modulate 226
- Acquisition 204
- Matched Filter 202
- Sum 208
- 5 • Subtract 212
- Convolve 236
- Multiply 240
- Time to Frequency Conversion (dependant on system standard)
234
- 10 • Time Domain Channel Estimator 232
- Frequency Domain Channel Estimator 238
- Time, Frequency Domain Multiplex 220
- Samples Estimate List (including associated Controller) 206
- Information Bit Estimates List (including associated Controller) 213

15 Table 1 and Table 2 provide a key for the number signals and process in each figure and the reference numbers in the text.

1002	Received Samples
1004	Windowed Matched Received Samples
1006	Empty Sample Estimates
108	Previous Packet Received Samples Estimate
110	Packet Received Samples Hypotheses
112	New Packet Information Bit Estimates
114	New Packet Received Samples Estimate
116	Noise Hypothesis
118	Completed Packet Information Bit Estimates
119	Packet Transmit Symbol Estimates
120	Time Domain Channel Applied Received Samples Estimate
122	Frequency Domain Channel Applied Received Samples Estimate
126	Hard Encoded Information Bits
128	Soft Encoded Information Bits
130	Time Domain Channel Estimate
132	Packet Transmit Samples Estimate
134	Frequency Domain Channel Estimate
136	Packet Received Symbol Estimates

Table 1: Signals

202	p(t) - Bandwidth Limiting Filter – Matched Filter
204	Acquisition
206	Samples Estimate List
208	Σ -Add
210	OFDM Soft/Hard Decode and Re-transmit
212	Σ (-ve) -Subtract
213	Information Bit Estimates List
214	OFDM Soft/Hard Decode and Re-modulate
215	Hybrid Re-transmit
216	TDCA – Time Domain Channel Application
218	FDCA – Frequency Domain Channel Application
220	MUX – Time, Frequency Domain Multiplex
222	OFDM Hard Output Decode
224	Encode
226	Hard Modulate
228	OFDM Soft Output Decode
230	Soft Modulate
232	Time Domain Channel Estimator
234	F→ T – 802.11a Frequency to Time Domain Conversion
236	Convolve – Linear Convolution
238	Frequency Domain Channel Estimator
240	Multiply

Table 2: Function Blocks

The second embodiment of the invention is adapted for a Packet based
 5 OFDM WLAN system (eg IEEE 802.11a, IEEE 802.11g). A typical receiver for
 such a system performs processing tasks in accordance with figure 10. The input
 to the system is a complex, oversampled baseband received signal 1002 for each
 attached antenna. The signal received on each antenna is passed through a
 band limiting filter 202 which is then followed by a packet detection and

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synchronisation (Acquisition) processing block 204. This Acquisition block uses one or more of the matched filter antenna signals 1004. Once a packet is acquired it is decoded using either hard or soft decoding techniques and passed on to a higher processing layer (eg. MAC). The typical receiver structure figure 5 10 may be modified to an iterative structure that provides interference cancelling at the sample level.

Iterative Receiver Structure & Function

The input to the receiver is the oversampled digital I/Q baseband samples from each antenna connected to the receiver called the Received Samples 1002. 10 The Received Samples 1002 are windowed over time and passed through a filter 202 matched to the pulse shape in order to produce windowed matched received samples 1004. This constitutes the Noise Hypothesis 116 for the first iteration ($n=1$). For all proceeding iterations ($n>1$), the Noise Hypothesis 116 is provided by the feedback of the interference signal. This is depicted in Figure 11 by the n 15 conditioned switch SW_n .

An iteration of the receiver is a single execution of each of the following processes:

- Attempt to acquire a new Packet in the Noise Hypothesis 116 using the Acquisition 204 process.
- 20 • If a new packet is found, add empty entries 1006 to the Samples Estimate List 206 and Information Bit Estimates List 213. Each entry in the Samples Estimates List 206 has a corresponding entry in the Information Bit Estimate List 213.
- Determine, from the evolution of both Samples and Information Bit estimates list, Completed Packets $\{y_1 \dots y_m\}$, in the Information Bit Estimates List 25 206.
- Release to higher layer (MAC) then Remove Completed Packets $\{y_1 \dots y_m\}$ from the Information Bit Estimates List 213.
- Remove Completed Packets $\{y_1 \dots y_m\}$ from the Samples Estimate 30 List 206.
- Select a Packet k in the Samples Estimate List 206 to Process.

- Add 208 the Previous Packet Received Samples Estimate 208 of selected packet k from the Samples Estimate List 206 to the Noise Hypothesis 116 to produce the Packet Received Samples Hypothesis 110.
 - Generate new Packet Received Samples Estimate 114 and new information bit estimates 112 for the selected packet k from the Packet Received Samples Hypothesis 110 using OFDM Soft/Hard Decode and Re-transmit process 210.
 - Update the selected packets' k previous information bit estimates in the Information Bit Estimates List 213 with the New Information Bit Estimates 112.
 - Update the selected packets' k previous Samples Estimate in the Samples Estimate List 206 with the New Packet Received Samples Estimate 114.
 - Subtract 212 the New Packet Received Samples Estimate 114 from the Packet Received Samples Hypothesis 110 to produce the Noise Hypothesis 116.
- Iterations are continually performed until all packets have been released from the Information Bit Estimates List 213. Once this state has been reached, the lists 206, 213 are cleared, the time window is updated and the entire process repeated.

Iterative Interference Cancelling

- Interference cancelling at the sample level requires the generation of New Packet Received Samples Estimate 114 for each antenna using the OFDM Soft/Hard Decode and Re-transmit 210 process for every Packet found by the Acquisition 204 process. Each packet's New Packet Received Samples Estimate 114 are stored in the Samples Estimate List 206. The interference cancelling structure requires that each packet Adds 208 its Previous Packet Received Samples Estimate 108 to the Noise Hypothesis 116 before the Soft/Hard Decode and Re-transmit 210 process to produce the Packet Received Sample Hypothesis 110 for each antenna. The New Packet Received Samples Estimate 114 produced by the Soft/Hard Decode and Re-transmit 210 process are then Subtracted 212 from the Packet Received Sample Hypothesis 110 to generate an updated Noise Hypothesis 116. The New Packet Received Samples Estimate 114 are also used to update the Samples Estimate List 206. The Noise

Hypothesis 116 is then fed back through the system (minus the latest estimated contribution of the previously processed packet) providing Iterative Interference Cancelling. Figure 11 provides a graphical reference for this process.

Samples Estimate List

5 The Samples Estimate List 206 contains the New Packet Received Samples Estimate 114 as generated by the OFDM Soft/Hard Decode and Re-transmit process 210 for each receive antenna for each Packet found by the Acquisition 204 process.

10 For each iteration, a packet to iterate (k) is selected from the Samples Estimate List 204. The selection k can be based on numerous metrics e.g., sorted signal power, the minimum number of processing cycles performed, order of arrival. This selection is depicted by the k controlled switch SW_k in Figure 11, where k is the current selected packet.

Information Bit Estimates List

15 The Information Bit Estimates List 213 contains the latest New Packet Information Bit Estimates 112 as generated by the OFDM Soft/Hard Decode and Re-transmit 215 process for each Packet found by the Acquisition 204 process.

20 Each iteration provides an opportunity to release Completed Information Bit Estimates 118 to higher layers (e.g. MAC). The choice of which packets are complete is made by evaluating a metric for each packet in the Samples Estimate List 206. For example, this metric may be based on indicators such as signal power, the number of iterations performed and number of completed packets. These metrics are then compared to a target value. All packets that meet their target are marked for release from the Information Bit Estimates List 213.

25 For each packet acquired there is an entry in both the Samples Estimate List 206 and the Information Bit Estimates List 213. The selection of completed packets is depicted by the $\{y_1 \dots y_m\}$ controlled switch SW_y in Figure 11, where $\{y_1 \dots y_m\}$ is the list of Completed Packet Information Bit Estimates. A feature of the iterative receiver structure is that the packet's Packet Received Samples Estimate 114 remain subtracted from the Noise Hypothesis 116 even after it is released and its corresponding entries in both lists removed.

30

Hybrid Re-transmission

The Hybrid Re-transmission 215 process is depicted in Figure 12 and Figure 13. It uses both Time Domain Channel Application 216 and Frequency Domain Channel Application 218 processes to generate a New Packet Received Samples Estimate 114. Both processes use the Packet Received Samples Hypothesis 110 for each antenna and Packet Transmit Symbol Estimates 119 to create Channel Applied Received Samples Estimate 120, 122 for each receive antenna. The Time Domain Channel Application 216 process produces a Time Domain Channel Applied Received Samples Estimate 120. The Frequency Domain Channel Applied Received Samples Estimate 122. The Channel Applied Received Samples Estimate 120, 122 are then multiplexed 220 together to form the New Packet Received Samples Estimate 113 for each antenna. Each of these processes is described in further detail below.

Time Domain Channel Application (TDCA)

The Time Domain Channel Application 216 process is further expanded in Figure 16. The Time Domain Channel Estimator 232 produces a Time Domain Channel Estimate 130 for each receive antenna using the Packet Transmit Symbol Estimates 119 from the OFDM Soft/Hard Decode and Re-modulate 214 process (see Figure 14 and Figure 15) and the Packet Received Sample Hypothesis 110 for each antenna. The Frequency to Time Conversion 234 then produces a Packet Transmit Samples Estimate 132 using the Packet Transmit Symbol Estimates 119. The Packet Transmit Samples Estimate 132 and Time Domain Channel Estimate 130 for each antenna are then linearly convolved via the Convolve 236 process to produce the Time Domain Applied Received Samples Estimates 120 for each antenna.

Frequency Domain Channel Application (FDCA)

The Frequency Domain Channel Application 218 process is further expanded in Figure 17. The Frequency Domain Channel Estimator 238 produces a Frequency Domain Channel Estimate 134 for each antenna using the Packet Transmit Symbol Estimates 119 from the OFDM Soft/Hard Decode and Re-modulate 214 process and the Packet Received Sample Hypothesis 110 for each antenna. The Packet Transmit Symbol Estimates 119 are then multiplied, one

OFDM symbol at a time, by the Frequency Domain Channel Estimate 134 via the Multiply 240 process to produce the Packet Received Symbol Estimates 136. The Packet Received Symbol Estimates 136 are then converted into the Frequency Domain Channel Applied Received Samples Estimate 122 using the
5 Frequency-To-Time process 234.

Time, Frequency Domain Channel Application Multiplexing (MUX)

Referring now to Figure 13, the Multiplexing 220 process takes the Time Domain Channel Applied Received Samples Estimate 120 and the Frequency Domain Channel Applied Received Samples Estimate 122 and multiplexes them
10 together to produce a hybrid New Packet Received Samples Estimate 114.

OFDM modulation scheme such as those used in this second embodiment, commonly employ a cyclic prefix to combat multi-path interference. Also, due to time dispersion characteristics of both the radio channel and band limiting filters, there are tails at the beginning and end of the New Packet
15 Received Samples Estimate 114. New Packet Received Samples Estimate 114 corresponding to the OFDM portion of the signal are taken from the Frequency Domain Channel Applied Received Samples Estimate 122. The remaining samples in the New Packet Received Samples Estimate 114 are taken from the Time Domain Channel Applied Received Samples Estimate 120. In this
20 embodiment those samples comprise the cyclic prefix and tail portions of the New Packet Received Samples Estimate 114.

An example of multiplexer mapping is shown in Figure 18.

Preferred Area of Application

The preferred areas of application for the second embodiment of the
25 present invention are OFDM receivers that may be used with IEEE 802.11a, IEEE 802.11g, IEEE 802.16 and HiperLAN Wireless Local Area Network (WLAN) standards. However, the invention disclosed is useable in any packed based OFDM communications system as would be understood by the person skilled in the art.

30 With reference to figures 19 to 23 a third embodiment is described which stems from the realization that reducing the distortions in one or more of the raw signals arriving at a receiver used to provide a decision statistic leads to an overall improvement in the decision statistic itself. Furthermore, appropriate

selection of the means of reducing these distortions leads to a more reliable determination of packet arrival time.

In one aspect the third embodiment provides a method and apparatus for communicating in a multiple access communication network by synchronizing
5 packets arriving at a receiver comprising:

receiving a packet input signal;

determining a correlation signal corresponding to the packet input signal;

processing the input and correlation signals such that at least one of the input signal and the correlation signal are filtered;

10 determining a decision statistic by combining a power component of the processed correlation signal with a power component of the processed input signal;

nominate a point in time given by a predetermined threshold condition of the decision statistic as a received packet arrival time.

15 The processing of at least one of the input and correlation signals is performed by one of a centre weighted filter having a triangular impulse response, a root raised cosine filter, a Hanning window filter, a Hamming window filter, or a combined Hanning/Hamming window filter. The predetermined threshold condition may be one of the decision statistic crossing the predetermined
20 threshold or a maximum of the decision statistic occurring above the predetermined threshold. The determination of the correlation signal may be performed every Kth sample of a sampled packet input signal, where K is an integer greater than or equal to 1. The third embodiment of the present invention is described in more detail below.

25 **Power averaging mask for FFT window synchronisation**

Synchronisation of packets transmitted, especially over wireless media, is ordinarily achieved by employing a preamble comprised of several repetitions of the same signal and correlating the received signal with a delayed version of itself. The delay may be chosen to equal the duration of the repeated signal
30 component defining the preamble. The output power of this correlation process is then usually normalised against the average power in the received signal. The point at which the normalised correlator output exceeds a threshold is selected as the packet arrival time. This technique has a number of deficiencies. For

example, it does not optimally exploit the statistics of the correlator outputs and thus may introduce larger error margins in the determination of data packet timing. In this third embodiment, a method is disclosed which permits a more accurate determination of arrival time of a data packet. Thus synchronisation errors may be reduced and, consequently, packet loss rates are reduced. Specifically, the method uses a linear filtering approach to interpret the correlator outputs prior to powers being calculated, thereby improving the quality of the statistic used for packet synchronisation. This is achieved primarily due to the noise suppression properties of the filter. The shape of the linear filter may be optimally designed against the characteristics of the preamble and the radio channel. An example would be a root raised cosine filter, or a Hanning/Hamming window filter. One preferred embodiment of the invention is the use of a centre weighted average filter with a triangular impulse response for application to the correlator outputs. This filter enables more accurate location of the time of the packet arrival than is achievable otherwise and has an efficient implementation. It is also proposed to use the maximum correlation power, once a threshold is exceeded, as the decision point rather than the time at which the correlation power first crosses a threshold. Those practiced in the art will recognise that this method has potential application to any communication system that uses a repetitive preamble for packet synchronisation. The inventor has recognised that filters are widely used in general applications and that the synchronisation of packets may be treated as a filtering problem. Accordingly, the inventor proposes to use raw correlator outputs as a preferred filter input. The use of a centre weighted (or other) filter on the correlator outputs prior to power calculation is used as a measure of the arrival timing of a packet. Threshold testing of the normalised power of the received signal correlated with a delayed version of itself is also contemplated. The delay is equal to the repetition size of the preamble. The normalisation is achieved by dividing by the sliding window averaged power of the received signal. In this third embodiment it is particularly advantageous to provide a receiver with the following functions:

Filtering of raw correlator outputs;

Centre weighted averaged filter, preferably a triangular filter which has an efficient implementation;

The above allows for basing a decision point on the maximum of correlator output power rather than a first level crossing leading to better characterisation of packet timing to avoid packet transmission loss/inefficiency. The third embodiment may comprise a receiver technology for packet data transmissions where a repetitive preamble is deployed to determine packet data timing and allowing for adaptive design of filter form against the statistics of the radio channel.

Field of Application

The third embodiment technology applies to a point to point communications link where transmissions are made using a waveform structure that has a preamble of a particular type. Specifically the preamble may be formed by one or more repetitions of a base signal. The functional device embodying the technology preferably resides in the baseband receiver processor Rx of a general receiver 190, as previously discussed and, in this embodiment, in the exemplary form of a wireless modem 190 as shown in figure 19. The relative logical location of the baseband receiver Rx is shown in figure 19 as the "Baseband Rx".

In more detail, in packet based communications systems the timing of the arrival of a packet is determined at the receiver 190. Once this timing is determined the alignment of the remaining (typically data bearing) portions of the packet may be determined using a-prior knowledge of the packet structure. Therefore without accurate determination of the packet time packet errors may be prevalent. A common technique employed is to transmit a preamble at the start of the packet transmission that has a special structure permitting efficient arrival time determination at the receiver 190. This structure requires the repetition of a short signal several times in the preamble. The structure of a typical packet is shown in figure 20 where the Sync Word (SW) is repeated several times at the beginning of the transmission.

The conventional time synchronisation technique correlates the received signal with a delayed version of itself. This delay may be set to the length of the Sync Word and the correlation length may be set to the number of SW repetitions (L) minus one. This correlation is implemented every sample (or every K^{th}

sample where K is small, e.g. 4). If the received sample sequence is $\{r_{i-1}, r_i, r_{i+1}, r_{i+2}, \dots\}$ then the correlator output at time i is

$$\rho_i = \sum_{j=i}^{i+N(L-1)} r_j^* r_{j+N}$$

This correlation value is compared with the power in the observed
5 sequence

$$\sigma_i = \sum_{j=i}^{i+N(L-1)} r_j^* r_j$$

to form a decision statistic $|\rho_i|^2 / \sigma_i^2$. The arrival time i is chosen when this
metric exceeds a threshold.

The inventor has identified that any noise present in the received
10 sequence r_i is amplified by the squaring process and may cause the
synchronisation technique to pick the incorrect arrival time. Rather than waiting
for the statistic to cross a threshold, the algorithm may be adjusted to select the
maximum statistic by including a small amount of decision delay. This maximum
is chosen from those statistics above the threshold. A number of statistics
15 crossing a given threshold is shown in figure 21.

Preferred Method

In this method according to the third embodiment of the invention the
inventor exploits the profile of the autocorrelation of the preamble in order to
mitigate the negative effects of noise of the time synchronisation performance.
20 This may be achieved by filtering the sequences ρ_i and σ_i by a centre weighted
low pass filter. Note that this filter is applied *prior* to the subsequent squaring of
the sequences for decision statistic generation. Any noise presence will be better
suppressed by filtering prior to squaring. The filter may be designed against the
autocorrelation properties of the preamble but in a preferred embodied a triangle
25 filter is employed.

A triangle filter has an impulse response that is triangular in nature,
specifically the coefficients (taps) of the (discrete time) filter are

$$f_i = \frac{N - |i|}{N^2}$$

as shown in figure 22. If the filter described above is applied to the underlying sequences (ρ_i and σ_i) then a typical result would be as shown in figure 23. It can be seen that the threshold crossing technique has benefited from the application of the filter, since it is now closer to the maximum as seen by inspection of figure 23. The effect of the noise has also been reduced therefore enhancing both the maximum and threshold crossing techniques. The preferred method is to apply the filter to both raw sequences, compute the metric using the filtered sequence and to use the maximum of the statistic that is above the threshold. Advantageously, a more accurate synchronisation of arrival time is achieved by filtering of the correlator output and power measurement processing prior to decision statistic generation; using a maximum search within a window defined by a threshold on the decision statistic.

By accurately estimating the arrival time of the preamble (and therefore the packet), the number of packet decoding failures may be significantly reduced. Apart from improving the chance of recovering the data payload this has flow on effects to the network users since both network control and data packets are now more reliably recovered.

With reference to figures 24 to 31 a fourth embodiment of the present invention is described in which the solution offered stems from the realization that receiver sensitivity may be improved by improving channel estimates using symbol estimates from the encoded portion of a packet and iteratively updating these channel estimates based on recently received data symbol channel estimates. A further aspect of the fourth embodiment resides in transforming each received data symbol to the frequency domain to enable the release of time smoothed channel estimates for improved decoding.

Advantageously, in the fourth embodiment, each OFDM symbol may be decoded more than once by obtaining a channel estimate for Symbol n, decoding symbol n, updating the channel estimate for symbol n, updating the channel estimate for symbol n-1 (by time domain smoothing from the new channel estimate for symbol n), decoding symbol n-1, updating channel estimate n-1.

In accordance with a fourth embodiment the present invention provides a method and system of tracking time varying channels in a packet based communication system comprising:

- 5 a) Initializing a channel estimate reference based on an initial channel estimate derived from a received packet preamble;
- b) updating the channel estimate reference based on a packet data symbol channel estimate in a coded portion of the current and all previous received data symbols;
- 10 c) repeating step b) at the arrival of subsequent packet data symbols.

The method preferably comprises storing the channel estimate reference in a channel estimate data base at the receiver. The method preferably comprises transforming the packet data symbol channel estimates to the frequency domain prior to updating the stored channel estimate reference to provide a time smoothed channel estimate reference. The method also
15 preferably comprises for each subsequent received data symbol within step b), pipelining the steps of demodulating, modulating, and updating the channel estimate reference with the further step of FEC decoding.

In the current state of the art, high mobility high bandwidth transmission of information is limited by the inability of receiver processing techniques or methods
20 to track the time varying nature of the radio channel and its effect on the transmitted signal and its waveform. Thus, related art systems for high mobility transmission support only low data rates. In this fourth embodiment, a receiver technique that exploits OFDM signal structures is disclosed and the fact that these OFDM signals are error control coded. Thus high mobility, high bandwidth
25 data transmission is permitted. Additionally, the technique also benefits fixed communication radio networks by improving receiver sensitivity. Specifically, the fourth embodiment has been achieved by developing an algorithm that permits the reliable decoding of OFDM modulated packets of information that have been distorted by a rapidly varying radio channel, but without the need for
30 compromising data rate by the excessive use of pilot or training signals.

In a preferred aspect of the fourth embodiment of the invention, an algorithm has been devised that may operate on a per OFDM symbol basis in order to avoid increased decoding latency and complexity. Correspondingly, in

this embodiment, three statistics are exploited: the frequency domain statistics of the radio channel at the OFDM symbol rate; time domain statistics of the radio channel across OFDM symbols and; the outcomes of each decoded OFDM symbol. These statistics are used to estimate the radio channel from OFDM symbol to OFDM symbol. When a new OFDM symbol arrives the channel and data estimates are updated for the corresponding symbol and some small number of previous symbols. In this manner each OFDM symbol is decoded more than once with an improved channel estimate each time. Prediction of the radio channel from the received signal and knowledge of the preamble of the packet is deployed to initialise the process. That prediction uses the statistics of the radio channel. It will be evident to those practiced in the art that this embodiment permits the effective decoding of OFDM packets in rapidly varying radio environments. Thus it offers benefits in terms of supporting increased mobility at increased spectral efficiencies. It achieves this without increasing the implementation complexity, or latency, while simultaneously increasing receiver sensitivity. In this regard, it has potential in both high mobility and in fixed wireless networks. Those practiced in the art will recognise that this embodiment may be applied to any wide band modulation technique that shares a common underlying channel model similar to the preferred embodiment above. Some examples are the addition of multiple receive antennas, multi-carrier OFDM or multi-carrier CDMA.

Advantageously, the fourth embodiment provides:

- Iterative channel and data estimation whereby the initial estimates are improved using data aided techniques.
- Frequency domain smoothing stored across OFDM symbols enabling release of time smoothed channel estimates for improved decoding.
- Decoder outcomes derive channel estimates stored in "CEDB" (channel estimate data base) described in more detail, below.
- Prediction of channel from CEDB to start up OFDM symbol loop based processing.
- Consequent low latency, high bandwidth high mobility data.

In this fourth embodiment a baseband digital receiver technology that enables the effective reception of high data rate signals from a mobile device travelling at high speed is disclosed. A brief performance analysis is also presented.

5 **Field of Application**

This technology applies to a point to point communications link where transmissions are made using coded Orthogonal Frequency Division Multiplex (OFDM). In general, coded OFDM transmissions are formed by

1. forward error correction (FEC) encoding, over one (OFDM) symbol
10 duration, the information bits, then
2. conventional OFDM modulation.

The FEC coding over one OFDM symbol may be block coded or the coding may continue across multiple OFDM symbols but per OFDM symbol decoding techniques must be available. The receiver will exploit the coding on
15 the OFDM symbols to improve performance.

As with the third embodiment, the functional device embodying the technology preferably resides in the baseband receiver processor Rx of a receiver 190 in the exemplary form of a wireless modem 190 as shown in figure 19. The relative logical location of the baseband receiver Rx is shown in figure 19
20 as the "Baseband Rx".

Latency and OFDM Symbol based Processing Loops

In packet based communications systems it is important to implement the receiver processing with as little delay between the arrival of signals and the decoding of the bits contained in the signal as possible. This is important since
25 the turn-around time for acknowledgements is a significant driver in the network performance. In OFDM modulated systems this requirement typically forces the use of per OFDM symbol processing. That is, when a new OFDM Symbols worth of signal arrives the Baseband Rx should release an OFDM symbols worth of information bits. The delay between the information enabling the decoding of an
30 OFDM Symbol and the outcomes of decoding the Symbol must be of the order of a few OFDM Symbols duration.

OFDM Channel Estimation in Mobile Environments

In mobile radio communications systems coherent receiver designs typically require the use of accurate channel estimation methods in the baseband receiver. The channel to be estimated is a multipath fading channel induced by motion and reflections in the field. Among other uses, the channel estimate is employed to drive the FEC decoder, a critical aspect of the receiver. In the case of OFDM modulated signals the channel is normally measured in the frequency domain, after the received signal has been sliced up into OFDM Symbol sized pieces. In mobile communications systems the channel over which the signal travels changes with time and, if the vehicle speed is high enough, the channel may change during the reception of a packet. In related art receiver techniques it is assumed that the multipath fading channel is invariant over the packet enabling the one-off estimation of the channel at the start of the packet. In most standards (e.g. IEEE 802.11a) a preamble is transmitted at the start of a packet for exactly this purpose.

Preferred Method

In this method according to a fourth embodiment the partitioning of the received signal for OFDM to provide a convenient boundary for tracking time varying channels is exploited. The channel estimate changes from OFDM Symbol to OFDM Symbol. The preferred embodiment also exploits the fact that the OFDM symbol is encoded, enabling the use of decoded data as training information for the channel estimator. The statistics of the way that the channel changes with time and frequency are also exploited here.

An estimate of the channel in the frequency domain is obtained. The inventor defines the CEDB as a Channel Estimate Data Base containing channel estimates for each OFDM symbol, smoothed in the frequency dimension (across sub-carriers), but not in the time dimension. The method comprises the following steps, as set out below, for a packet with N OFDM symbols. Steps required for OFDM window synchronization occur prior to the processing shown here. The inner loop (3.4) is of length, L, OFDM Symbols and enables iterative channel and data estimation.

Ref	Function
1	Estimate Time and Frequency Offsets based on Preamble
2	Initialise CEDB based on Preamble
3	For Each OFDM Symbol ($n=1:N$) {
3.1	Transform Rx OFDM Symbol into Frequency Domain (apply FFT)
3.2	Correct Rx OFDM Symbol for Time and Frequency offsets
3.3	Generate Channel Estimate for OFDM Symbol n by prediction from CEDB
3.4	For Each recent OFDM Symbol ($m=n-1:n-L$) {
3.4.1	Demodulate OFDM Symbol m using Channel Estimate
3.4.2	FEC Decode OFDM Symbol (outcomes also released to upper layer)
3.4.3	Generate Training by remodulating FEC Decoder Outcomes
3.4.4	Update CEDB using Training and Corrected Rx OFDM Symbol
3.4.5	Generate Channel Estimate for OFDM Symbol $m-1$ from CEDB
	}
	}

The channel prediction (step 3.3 above) and generate channel estimate (step 3.4.5 above) both apply CEDB time domain smoothing across OFDM symbols in their implementation. The strength of the smoothing (across Sub-Carrier and OFDM Symbol dimensions) are independently controlled by a process not described here.

Advantageously, the fourth embodiment provides:

1. Iterative Channel and Data Estimation whereby the initial estimates (resembling those that would be obtained conventionally) are improved (step 3.4) using data aided techniques.
2. Frequency Domain Smoothing stored across OFDM Symbols enabling release of time smoothed channel estimates for improved decoding (steps 2, 3.4.4).
3. Decoder outcomes drive channel estimates stored in CEDB (steps 3.4.3, 3.4.4).

4. Prediction of Channel from CEDB to start up loop based processing (step 3.3).

Parallelism may be exploited for implementation purposes by two processes running in parallel comprising.

- 5 1. demodulation, modulation and channel estimation stages (steps 3.4.1, 3.4.3, 3.4.4 & 3.4.5), and
2. FEC Decoding (step 3.4.2)

While Process 1 is working on OFDM Symbol n, Process 2 is working on OFDM symbol n-2. This offset requires the predictor in Ref 3.3 to look ahead one
10 extra OFDM symbol.

The benefits obtained by use of this embodiment's technology are now described.

Complexity

By exploiting pipelining of the FEC decoder function the most difficult
15 aspect of the receiver device is fully exploited while maintaining a highly adaptive capability in terms of the propagation environment.

Sensitivity

By accurately estimating the channel, the performance of the decoder stage may be significantly improved (typically in excess of 1 dB increase in
20 receiver sensitivity). This has been found to be the case even for time-invariant channels and is realized by exploiting data symbols for training purposes. In the case where mobility exists the ability of the receiver to track the channel in time allows the receiver to operate effectively where conventional systems may fail. At the same time, the benefits of iterative (multi-visit) estimation of the data symbols
25 are realized.

Latency

By employing per OFDM symbol processing and pipelining the FEC decoder the inventor has obtained the earliest possible release of high quality data estimates. Therefore the receiver operates without increasing latency
30 relative to conventional techniques. It should be noted that conventional techniques may fail in high speed mobile conditions. Performance Analysis

In this section an example of the data and channel estimates that are obtained using conventional, idealised and the proposed receiver processing

techniques are provided. The attributes of the communications link used in the example are shown in the table below.

Quantity	Value	Unit
Bandwidth	16.0	MHz
Carrier Frequency	5.0	GHz
Number SubCarriers	256	SubCarriers
OFDM Symbol Duration	16	us
OFDM Symbols Per Packet	38	OFDM Symbols
Mobile Unit Velocity	30	ms ⁻¹
CoherenceFrequency	3.0	MHz
Bits Per SubCarrier	2	Bits
Pilot SubCarrier Spacing	32	SubCarriers
Eb/No	8.0	dB
FEC Rate	1/2	
FEC Memory	5	
Derived		
Channel Coherence Frequency	48.0	SubCarriers
Channel Coherence Time	62.5	OFDM Symbols
Packet Length	640.0	us
Doppler Frequency	0.5	kHz

The actual radio channel (measured after FFT application in the receiver) is shown in Figure 24. The rapid phase rotations in the Phase plot result from FFT window misalignment and residual intermediate frequency in the down-conversion step. These are both real-world impairments. The receiver estimates both of these parameters and may be compensated for them on a symbol by symbol basis. The result of this correction is shown in Figure 25. Note that this figure represents the actual radio channel corrected by an estimated quantity and is shown here for assessment purposes. An objective of the receiver is to accurately estimate this corrected channel.

Conventional Processing

In conventional processing the radio channel is estimated based on the preamble only. The main restriction with this approach is that the radio channel (after correction) must be invariant across the frame. As shown in figure 25 this is not the case since there is a phase change at around OFDM symbol 30 in some of the sub-carriers. It is therefore expected that decoder failures starting at around OFDM Symbol 30 of the packet will occur. This is indeed the case as shown in figure 26.

Preferred Method (Perfect Training Symbols)

Figure 28 shows the performance of the proposed system is shown with the possibility of decoder failures for training symbol generation eliminated. The decoder outcomes for data recovery are still recorded hence the errors in figure 28. This represents the best possible case for data aided radio channel estimation. It is possible to compare this result with that obtained using decoder outcomes for training in the following section. Note that the number of errors has dramatically reduced relative to the conventional technique.

Preferred Method

In this section the performance of the proposed method is evaluated. The CEDB is shown in figure 29 and represents a good estimate of the radio channel even though smoothing across OFDM symbols has not been employed. The smoothing across sub-carriers is however evident. Once the smoothing across OFDM symbols is employed a very good match to the actual radio channel is observed, as shown in figure 28. As can be seen in figure 28 and figure 29 the error obtained using the proposed method results in the same error pattern as the idealised method. The error performance is vastly superior to the conventional method as shown in figure 26.

With reference to figures 30 to 34 a fifth embodiment is described, which stems from the realization that receiver sensitivity may be improved by use of the outputs of a receiver's decoder as additional pilot or training symbols and updating these iteratively with each symbol received for the recalculation of a channel estimate, and frequency and time offsets as they vary throughout a packet.

In one aspect the fifth embodiment provides a system and method of communicating in a multiple access packet based network by estimating time varying channel impairments, where channel impairments comprise channel variation, signal frequency offset and signal time offset, comprising:

- 5 a) initializing a set of channel impairment estimates based on initial pilot and preamble symbols included in a received packet;
- b) performing a decoder operation which comprises processing the set of channel impairment estimates and the received packet to determine a set of transmit symbol estimates;
- 10 c) updating the set of channel impairment estimates through use of the determined set of symbol estimates and received packet;
- d) repeating steps b) and c).

In another aspect the fifth embodiment provides a system and method of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, comprising:

- 15 a) estimating a frequency offset based on information included in a received packet preamble;
- b) correcting a received signal using the estimated frequency offset;
- c) determining a channel estimate using information included in the received packet preamble;
- 20 d) transforming a sample sequence of the received signal into the frequency domain such that the sample sequence includes OFDM symbols and intervening cyclic prefixes;
- e) performing a decoding operation which comprises processing the determined channel estimate and received packet;
- 25 f) generating a transmission sample sequence using the decoding results and information in the received packet preamble;
- g) transforming the transmission sample sequence into the frequency domain;
- 30 h) updating the determined channel estimate by combining the received sample sequence and the transmission sample sequence in the frequency domain;
- i) repeating steps e) to h).

In a further aspect the fifth embodiment provides a system and method of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, where the receiver retrieves OFDM symbols from a received signal and transforms the retrieved symbols to the frequency domain, comprising:

5 a) determine a matrix of training symbols comprised of symbol estimates derived from a decoder;

b) determine a matrix of frequency domain received OFDM symbols;

10 c) determine an intermediate channel estimate matrix by multiplying the OFDM symbol matrix by the conjugate of the training symbol matrix;

d) determine an intermediate matrix of training weights comprising the absolute value of the training symbol matrix;

e) perform a smoothing operation on both intermediate matrices comprising 2 dimensional filtering;

15 f) determine the channel estimate by dividing the smoothed channel estimate matrix with the smoothed training weight matrix.

In yet another aspect the fifth embodiment provides a system and method of communicating in a multiple access network by estimating offsets in a receiver for receiving transmitted packets, comprising:

20 a) determine a matrix of received OFDM symbols;

b) determine a matrix of conjugated data symbols wherein the data symbols comprise one or more of preamble, training and estimated symbols;

c) determine a 2 dimensional Fourier transform matrix comprised of the received symbol matrix multiplied with the conjugated symbol matrix;

25 d) filter the Fourier transform matrix;

e) determine time and frequency offsets by locating peak power occurrences within the filtered Fourier transform.

The fifth embodiment provides reliable estimation of channel impairments. In the related art, that is, in the theoretical rather than practical context, decoder outcomes are employed to assist with the estimation of channel coefficients and synchronisation of received signals in radio communications systems and radio networks. The difficulties encountered with these present theoretical approaches to decoder outcomes include the appropriate treatment of the uncertainty of these

decoder outcomes in what would otherwise be conventional channel estimation and synchronisation techniques. In other words, the difficulty of applying one-shot or preamble-only channel estimation techniques or processing to an iterative process leads to less efficient and less accurate channel estimate and synchronisation performance. With this in mind, in this embodiment the use of a channel estimation and a synchronisation technique that employ an entire packet's worth of decoder outcomes (in addition to the preamble) is described. While others also have advocated this approach (at least in general terms), in the present embodiment, the specific method to manage uncertainty in the decoder outcomes and subsequent processing are distinguished from the related art by the features described here below. In this embodiment, in estimating the channel, the inventor first employs the frequency domain version of the remodulated decoder outcomes and preamble as training symbols. Then compute the frequency domain channel estimate from this training symbol sequence and from the frequency domain version of this the received signal. This may be achieved by either division or by minimum mean square error estimation or, via other estimation techniques. Any errors in the decoder outcomes will be dispersed similar to the use of an interleaver and not have direct impact on a local region of the channel estimate.

It should be noted that the channel estimation approach of the fifth embodiment is able to track the channel as it varies across the packet by slicing the packet up into segments that are assumed invariant. Thus the practical impact of this embodiment is that more reliable channel estimates provide the opportunity for significantly improved information packet recovery in radio communications.

In another aspect, the synchronisation technique, the inventor employs the preamble and decoder outcomes to remove the effects of data modulation on the received signal and then applies a 2 dimensional Fast Fourier Transform. By then executing a peak power search estimates of both the residual time and frequency offsets are obtained. These may then be employed to enable effective synchronisation.

In another aspect a channel estimator has been provided. This aspect employs the outcomes of soft FEC Decoding (e.g. SOVA) to improve the quality

of the radio channel estimate so that repeating the decoding step, using the new channel estimate, offers improved outcomes. These soft outputs are used to generate soft training symbols. Firstly, multiply the received OFDM Symbol matrix by the conjugate of the Soft Training symbols to get an intermediate raw channel estimate. Then compute a further intermediate matrix of training weights equal to the absolute value, or absolute value squared, of the each of the soft training symbols. Both of these matrices are then smoothed using filters based on channel statistics. The channel estimate is then obtained by dividing the smoothed raw channel estimate by the smoothed training weight matrix in an element wise fashion. The impact of this aspect on high mobility, high data rate communications networks will be evident to those practiced in the art. Accordingly, lower packet loss rates impact on network capacity. The method also increases the ability to accommodate rapidly changing radio channels and more reliably decode data transmissions. Likewise, increased receiver sensitivity leads to reduced packet loss rates and increased range for OFDM based systems with high velocity nodes.

The following acronyms are used in this description of the fifth embodiment.

APP	A-Posterior Probability
DSP	Digital Signal Processor
FEC	Forward Error Correction
FFT	Fast Fourier Transform
IF	Intermediate Frequency
IFFT	Inverse FFT
OFDM	Orthogonal Frequency Division Multiplex
RF	Radio Frequency
SOVA	Soft Output Viterbi Algorithm

This fifth embodiment of the invention provides a suite of baseband digital receiver technologies that enables the effective reception of high data rate signals from a mobile device travelling at high speed.

Field of Application

This suite of technologies applies to point to point communications links where transmissions are made using coded Orthogonal Frequency Division Multiplex (OFDM). As noted above, coded OFDM transmissions are formed by

- 5
- forward error correction (FEC) encoding, over one (OFDM) symbol duration, the information bits, then
 - conventional OFDM modulation.

The FEC coding over one OFDM symbol may be block coded or the coding may continue across multiple OFDM symbols but per OFDM symbol decoding techniques should be available. The receiver may exploit the coding on
10 the OFDM symbols to improve performance.

Typically the technology resides in the baseband receiver processor of a wireless modem. This location is shown in figure 19 as the "Baseband Rx"

In packet based communications systems it is important to implement the
15 receiver processing with as little delay between the arrival of signals and the decoding of the bits contained in the signal as possible. This is important since the turn-around time for acknowledgements is a significant driver in the network performance. In OFDM modulated systems this requirement typically forces the use of per OFDM symbol processing. However as signal processing capabilities
20 improve it is envisaged that another, more powerful option, will become available to system designers. The more powerful technique will employ the entire observation in making decisions about every bit transmitted (e.g. Turbo Codes). In current techniques only a portion of the received signal is employed to assist with the decoding of any particular information bit. Typically, a local channel
25 estimate may be formed using a portion of the observation and then decoding for that portion may be executed. The benefit of employing the observations, to follow, to assist with channel (or any other unknown parameter) estimation is currently not realised due to implementation complexity and performance of currently available DSP technology. Here the fifth embodiment provides
30 techniques that employ the entire observation to improve the channel estimation and hence reduce decoder errors. In addition, the transmitted waveform is often structured to permit per OFDM symbol processing at the receiver. If this

requirement is relaxed, frame based channel coding techniques may be applied to further improve the performance of the communications link. Examples of these techniques are the use of packet level interleaving and Block (e.g. Turbo) coding which may offer large performance benefits.

5 **OFDM Channel Estimation In Mobile Environments**

In mobile radio communications systems coherent receiver designs require the use of accurate channel estimation techniques in the baseband receiver. The channel to be estimated is a multipath fading channel induced by relative motion and multiple propagation paths between the transmitter and receiver and residual errors due to Transmit/Receive radio mismatch. The channel estimate is employed, among other uses, to drive the FEC decoder, a critical aspect of the receiver. In the case of OFDM modulated signals the channel is normally measured in the frequency domain, after the received signal has been separated

10 into OFDM Symbol sized pieces and transformed via the application of an IFFT. In mobile communications systems the channel over which the signal travels changes with time and, if the vehicle speed is high enough, the channel may change over the duration of a packet. This translates to the channel experienced at the start of the packet being substantially different that experienced at the end of the packet when viewed from the receiver. Related art receiver techniques assume that the multipath fading channel is invariant over the packet, enabling the calculation of a single channel estimate at the start of the packet to decode the entire packet. In most standards that use OFDM transmission schemes (e.g. IEEE 802.11a) a preamble is transmitted at the start of each OFDM symbol in order to permit estimation of the radio channel at the start of the packet.

25 However, the quality of the communications link may be increased by employing the use of data aided techniques in the estimation of the radio channel. In this case, the result of applying the FEC decoder on the received signal generates an estimate of the transmitted symbols which, while not absolutely accurate, are suitable for exploitation as additional pilot symbols. Typical examples of data aided channel estimation for OFDM are implemented in the frequency domain and therefore suffer power losses due to discarding of the cyclic prefix from each received OFDM symbol. The discarded cyclic prefix is theoretically useful for channel estimation and typically accounts for 10-50

percent of the received signal energy. Since the transmitted symbols determining the cycling prefix may be estimated at the receiver, this energy is potentially useful, as illustrated below, in the estimation of the radio channel and should not be discarded.

5 Frequency and Time Offset Estimation

Frequency offset arises due to the imprecise down conversion of the received signal from RF or IF to baseband. Time Offsets are commonly caused by inaccuracies in the packet arrival time estimation due to the impact of multipath fading channel and noise. Multipath, or Time dispersive, channels
10 result in multiple copies of the transmitted packet arriving at the receiver at different times therein decreasing the certainty in the time of arrival of the packet. Conventionally, estimates of the frequency and time offsets are initially made using the preamble of the packet and maintained using pilot symbols, inserted by the transmitter, throughout the packet (e.g. 802.11a). An example of this packet
15 format for 802.11a is shown in figure 30.

Frequency offsets manifest as inter carrier interference and a constant phase rotation across OFDM Symbols and Time offsets manifest as phase rotations across the OFDM Sub-Carriers. The inventor assumes that fine Inter-frequency offset estimation is required consistent with the residual errors after an
20 initial frequency offset correction. The phase offsets induced in the received symbols are due to the combined effects of the data modulation, transmission across the radio channel, imprecision in the frequency synchronisation during down conversion and imprecise time of alignment of the OFDM symbols during the time to frequency conversions. In order to estimate the radio channel, the
25 effect of the data symbols (be it preamble, pilot or unknown) on the received signal must first be removed, thereby leaving only the effect of the radio channel and time/frequency offsets. In the case of preambles and pilots the symbols are known a-priori and hence their removal is possible at the receiver. Using related art methods, the parts of the observation that are effected by data are not
30 available to aide in the estimation of the frequency and time offsets since the data symbols are not known at the receiver. The fifth embodiment, however, employs data aided techniques to significantly improve the performance of the estimation by making many more symbols available to the estimation process.

Proposed Method

The method proposed here is an iterative process that uses the outputs of the decoder as additional pilot symbols for recalculation of the channel estimate and for the recalculation of the frequency and time offsets as they vary across the packet. Collectively herein we shall refer to effects of the multipath channel combined with the frequency offsets induced by the RF or IF to baseband conversion and the time offsets caused by time misalignments in the time to frequency conversion as channel impairments. On the first iteration, the channel impairments are estimated using the pilot and preamble symbols nominated by the transmission scheme. These estimates are used to drive the initial execution of the decoder and generate the first transmit symbol estimates. Iterations thereafter use the transmit symbol estimates of the previous iteration as new pilot symbols to aid in the estimation of the channel impairments. The new channel impairment estimates are then used to re-run the decoder and generate new symbol estimates. This process may be repeated I times where I is the number of iterations and is an integer greater than equal to zero.

The details of the specific channel impairment estimators will be described in the following sections.

Channel Estimation

Two methods are available for estimation of the radio channel. One may be used when the radio channel is said to be invariant over the duration of the packet or discrete subsection thereof. The other is applicable when the radio channel varies over the duration of the packet.

Sequence Based Channel Estimation for OFDM

The sequence based channel estimator described here applies when the channel is invariant over a packet or, any substantial fraction thereof. This technique exploits all of the available received energy and is implemented prior to the OFDM symbol slicing conventionally employed in receivers for OFDM signals. The steps executed are as follows

Ref	Function
1	Estimate Frequency Offset using Preamble
2	Correct Received Signal for Frequency Offset
3	Estimate Channel using Preamble
4	Convert Rx Sample Sequence to Frequency Domain
5	For Some Number of Iterations {
5.1	Decode Packet using Current Channel Estimate
5.2	Generate Tx Sample Sequence using Decoder Outcomes & Preamble/Pilots
5.3	Convert Tx Sample Sequence to Frequency Domain
5.4	Estimate Channel By Dividing Rx Sample and Tx Samples in Freq Domain
	}

Steps 1 through 3 are common operations performed in typical OFDM receivers. Step 4 would not normally be found in an OFDM receiver. Conventionally the received sequence is sliced up into small OFDM Symbol periods, separated by Cyclic Prefix regions which are discarded. Each of these OFDM Symbols is transformed into the frequency domain by an FFT for processing (channel estimation, decoding, etc) as in step 5.1. Step 4 converts all parts of the received sample sequence that represents an entire packet or, selected portion thereof, including the cyclic prefix regions into the frequency domain to enable frequency domain channel estimate at the sequence level. This requires the other steps (5.2 and 5.3) which produces a hypothesis of the entire packet's frequency domain transmitted signal. In the frequency domain the received signal is equal to the transmitted signal multiplied by the channel plus any noise. This fact is exploited in step 5.4. The step in 5.4 could be replaced with an optimal linear estimator based on the Minimum Mean Squared Error criterion.

Channel Estimation with Soft Training Symbols

The channel estimator described here operates in the frequency domain of a conventional OFDM receiver. It is assumed that the received signal has been sliced up into OFDM Symbols, the Cyclic prefix discarded and the resulting OFDM Symbols converted to the frequency domain, via the use of an FFT. These processes are found in conventional OFDM receivers. The proposed method of the fifth embodiment is an iterative process that uses the symbol estimate outputs of the FEC decoder as additional pilot symbols or "Soft Training Symbols" in a re-estimation of the radio channel. By doing so (while noting these symbol estimate outputs may not be precise) the estimate of the radio channel is improved such that a subsequent execution FEC decoder produces an improved result over the previous execution.

Many different types of "soft output" decoders are available presently, including Soft-Output Viterbi Algorithms (SOVA), A-Posteriori Probability (APP) Decoders and various types of Turbo Codes. These soft outputs are used to generate soft training symbols according to techniques that may be found in the relate art literature, which would be understood by the person skilled in the art. It is the use of these soft training symbols which requires careful consideration and an improved technique is proposed here.

In the absence of noise, and other impairments, a received OFDM Symbol is equal to the multiplication of the transmitted OFDM Symbol and the frequency domain channel. If an OFDM system has N sub-carriers (frequency bins) then we may define vectors of length N to represent the transmitted data d_i and radio channel h_i for some OFDM Symbol period i . The received OFDM symbol in this case is $r_i = d_i .* h_i$, where the operator $.*$ corresponds to element-wise multiplication of the vectors. In the case where d_i is known perfectly at the receiver (e.g. if it were a pilot symbol) then the channel could be recovered perfectly in this ideal noise free case as

$$\hat{h}_i = r_i ./ d_i = h_i$$

where, similar to the $.*$ operator, the $./$ operator corresponds to an element-wise division of the vector elements. In data aided techniques the decoder outcome, \hat{d}_i is used instead of the actual transmitted data. This

estimate is subject to errors. The fifth embodiment involves a technique that accounts for this uncertainty in the "training" symbols. The method may be employed for time varying or invariant radio channels and takes a slightly different form depending of the channel variation. The following is a description of the estimator for time varying radio channels.

Assume the following is provided:

1. an entire packets worth of received OFDM Symbols R , and
2. an entire packets worth of soft training symbols D (some may be "hard" pilot symbols).

It is possible to structure these two objects as matrices as shown in figure 31 for M sub-carriers and N OFDM Symbols, where the rows are sub-carriers (tones or frequency bins) and the columns are OFDM Symbols (time).

Firstly, multiply the received OFDM Symbol matrix by the conjugate (denoted X^*) of the Soft Training symbols to get an intermediate raw channel estimate $V = R * D^*$. Note that the conventional step (as described above) would prescribe a division, not a multiplication. Then compute a further intermediate matrix of training weights $T = |D|$ or other functions such as absolute value squared. Then apply smoothing to both of these matrices using a two dimensional filter (f) matched to the channel coherence time and frequency. This filter outcome may be approximated by implementing smoothing independently in the time and frequency domains (rows then columns or vice versa) to save complexity. The estimate of the time varying channel is then derived as

$$\hat{H}_i = f(V) ./ f(T) = f(R * D^*) ./ f(|D|)$$

The uncertainty in the decoder outcomes is accounted for in the step where the absolute value of the training symbols was obtained. Small training symbols result from uncertain soft output from the FEC decoder step. A soft output FEC decoder will output a zero when a reliable estimate cannot be determined. Multiplication (in the $R * D^*$ step) by a zero effectively excludes that symbol estimate from the channel estimation process. Note that in the next iteration the symbol estimate may have firmed up, due to improved statistics driving the FEC decoder, increasing its reliability and therefore it may now be

included in the channel estimation process. In the ideal case the decoder will output correct, hard decisions and all data symbols will be used as perfect training to yield a very accurate channel estimate.

In the case that the channel is assumed time invariant across the packet the filtering function simply adds up the column and resulting in a column that is assume to apply over the entire packet.

In some cases, an approach whereby the two dimensional filter f applied to the raw channel estimate and training weight is different may be warranted. In these cases the time varying channel estimate would be

$$\hat{H}_1 = f_1(V) \cdot f_2(T) = f_1(R \cdot D^*) \cdot f_2(D)$$

where f_1 and f_2 implement different filters.

Joint Time and Frequency Offset Estimation using 2D FFT

In this aspect of the fifth embodiment we remove the effect of the data on the phase difference between adjacent symbols in the OFDM received matrix as shown in figure 31 and then apply a 2 Dimensional FFT. This removal may be achieved by multiplying the observed OFDM Symbol matrix with a corresponding matrix of conjugated data symbols be they preamble, training or estimated. The FFT output is then filtered to suppress noise, and a search for the peak power across the resulting 2 Dimensional space of metrics is executed. The filtering will have an impact on the maximum offsets that may be measured and it is therefore recommended that only very weak filtering be employed. The location of the peak, in terms of relative position in the rectangle of figure 31, determines the time and frequency offsets.

The granularity and range of the estimation is limited as follows. If there are M Sub Carriers and N OFDM Symbols then the range and resolution available from this technique is as shown in the following

	Resolution	Limit
Frequency Offset	OFDM Symbol Frequency / N	OFDM Symbol Frequency
Time Offset	OFDM Symbol Duration / M	OFDM Symbol Duration

An example for the system parameterised by is now given.

<i>Parameter</i>	<i>Value</i>
Number Of Tones	256
Number Of Symbols	20
Coherence Tones	40
Coherence Symbols	50
Actual Freq Offset	0.05
Actual Time Offset	0.20

With the actual channel amplitude and phase shown in figure 32 and figure 33 we get the metric shown in figure 34 for peak detection. Note that the peak is in the expected relative position, i.e. a fraction of 0.05 along the OFDM Symbol dimension and a fraction of 0.2 along the sub-carrier dimension. These estimates match the actual time and frequency offsets as shown in the above table of parameter values in the model.

By accurately estimating the channel, the performance of the FEC decoder stage is significantly improved, typically in excess of 1 dB increase in receiver sensitivity. This is true even for time-invariant channels and is realized by exploiting data symbols for training purposes. In the case where mobility exists the ability of the receiver to track the channel in time allows the receiver to operate effectively where related art systems may fail. At the same time, the benefits of iterative estimation of the data symbols are realized.

In a sixth embodiment the present invention provides a solution predicated on the use of firstly correlating the received signal at each antenna of a multiple access communication network with a known signal preamble and then statistically combining the correlated signal sequence of each antenna based on estimated antenna signal strength. It should be noted that in order to determine the coefficients for combining an initial timing estimate must be determined. The calculation of these coefficients will require, in practice, initial coarse timing and frequency offset estimation by other means. The quality of the initial timing estimate may be worse than that desired ultimately. The inventor considers further processing on the combined signal will lead to a timing estimate of high quality.

In a first aspect the sixth embodiment provides a system and method of communicating in a multiple access packet network by synchronizing a received signal in a multi antenna receiver comprising:

- 5 correlating a received signal observation at each of a plurality of antennae with a known signal preamble to provide a received signal sequence;
- determine a power signal of each received signal sequence;
- combine the determined power signals in accordance with a time averaged weighting based on estimated antenna signal strength for each antenna;
- 10 determine a time of arrival for the received signal in accordance with a predetermined threshold condition.

An preferred aspect of the sixth embodiment of the invention comprises:

- determining an estimate of the relative phase and amplitude coefficients of a receiving channel for each antenna;
- combining a received signal with the estimated coefficients to provide a
15 composite signal;
- determining a time of arrival of the received signal by correlating the composite signal with a delayed version of itself.

In related art, metrics used for synchronisation are based on outputs of correlators for the preamble of a packet. In the case of multiple receive
20 antennae, a method for either combining or deriving a new method of metric generation for synchronisation is desirable. Related art schemes propose making decisions per antenna and then majority voting or adding the metrics prior to decision. Neither of these approaches addresses sufficiently the variation of the signal statistics across antennae. The net result of this is degraded
25 synchronisation accuracy and increased packet loss rates. A further issue relates to the effective use of multiple antennae for data carriage but poor use of multiple antennae for synchronisation. In this case packets that could otherwise be decoded may be missed by the synchronisation module.

In this sixth embodiment, we disclose a method for determining per
30 antenna metrics and for subsequent combining across antennae in order to generate a metric for time of arrival estimation. The method involves essentially two steps. The per antenna metrics are derived by correlating the received signal with a known preamble in a first step. The power of the sequences for each

antenna is determined and added across antenna according to the time averaged weight based on estimated antenna signal strength. A threshold is then applied in order to determine the time of arrival.

5 A further aspect of the sixth embodiment relates to obtaining a rapid estimate of the relative phase and amplitude of the channel on each antenna and then to combine the received signal according to the conjugate of these coefficients. The processing would then proceed as in the related art with correlation of this composite signal with a delay version of itself. Application of this aspect of the sixth embodiment is in the synchronisation of wireless
10 communication links involving the simultaneous use of multiple receive antennae where the multiple antennae are used to increase the robustness of the communications link primarily through increased diversity.

In a further aspect, the signals from each antenna are combined according to Minimum Mean Square Error criteria where the combining coefficients are
15 dependent on a background noise measure on each antenna as well as the received signal energy. The processing would then proceed as in the related art with correlation of this composite signal with a delay version of itself.

It is particularly advantageous that the sixth embodiment provides for: a combining method for the metrics over antennae; currently does not require
20 OFDM specific characteristics, and; a version with OFDM specificity may be defined for clarity.

It will be appreciated by those skilled in the art, that the invention is not restricted in its use to this particular application described, neither is the present invention restricted to its preferred embodiment with regards to the
25 particular elements and/or features described or depicted herein. It will be appreciated that various modifications can be made without departing from the principles of the invention. Therefore, the invention should be understood to include all such modifications within its scope.

While this invention has been described in connection with specific
30 embodiments thereof, it will be understood that it is capable of further modification(s). This application is intended to cover any variations uses or adaptations of the invention following in general, the principles of the invention and comprising such departures from the present disclosure as come within

known or customary practice within the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth.

As the present invention may be embodied in several forms without departing from the spirit of the essential characteristics of the invention, it should be understood that the above described embodiments are not to limit the present invention unless otherwise specified, but rather should be construed broadly within the spirit and scope of the invention as defined in the appended claims. Various modifications and equivalent arrangements are intended to be included within the spirit and scope of the invention and appended claims. Therefore, the specific embodiments are to be understood to be illustrative of the many ways in which the principles of the present invention may be practiced. In the following claims, means-plus-function clauses are intended to cover structures as performing the defined function and not only structural equivalents, but also equivalent structures. For example, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface to secure wooden parts together, in the environment of fastening wooden parts, a nail and a screw are equivalent structures.

"Comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof."

References

[1] M.C. Reed, C.B. Schlegel, P.D. Alexander, and J. Asenstorfer, "Iterative multiuser detection for CDMA with FEC: Near-single-user performance," *IEEE Trans. Commun.*, pp. 1693-1699, Dec. 1998.

[2] S. Marinkovic, B.S. Vucetic, and J. Evans, "Improved iterative Parallel interference cancellation for coded CDMA systems," in the Proc. *IEEE Int. Symp. Info. Theory*, (Washington D.C.), p.34, July 2001.

[3] D.E. Catlin, *Estimation, Control, and the Discrete Kalman Filter*, Springer Verlag, 1989.

[4] P.D. Alexander, A.J. Grant, and M.C. Reed, "Iterative detection on code-division multiple-access with error control coding," *European Transactions on Telecommunications*, vol. 9, pp. 419-426, Sept.-Oct. 1998.

CLAIMS

1. An iterative decoding circuit for a wireless multiuser communications receiver comprising:

5 a first signal processing means for receiving at least one received signal, said first signal processing means comprising at least two linear iterative filters such that:

the first linear iterative filter provides an estimate of a selected received signal to an estimated signal output and;

10 a second linear iterative filter provides estimates of at least one other received signal, delayed by one iteration cycle, to an input of said first linear iterative filter;

a second signal processing means for receiving the estimated signal output of the first linear iterative filter and providing a further received signal estimate to the input of the first signal processing means in a succeeding iteration cycle of the decoding circuit.

15

2. An iterative decoding circuit according to claim 1, wherein the linear filters function in accordance with at least one predetermined recursive Bayesian expression.

20

3. An iterative decoding circuit according to claim 2, wherein the predetermined recursive expression comprises the following recursive Bayesian estimation using the following assumptions:

25 **A1:** *The received signal is described as $\mathbf{r} = \mathbf{S}\mathbf{x} + \mathbf{n}$, where \mathbf{S} is the constraint matrix, containing all the linear channel constraints, \mathbf{x} is a vector containing all transmitted information symbols and \mathbf{n} is circularly symmetric complex Gaussian with covariance matrix $\text{cov}\mathbf{n} = \sigma^2\mathbf{I}$, and where the noise variance σ^2 and the constraint matrix \mathbf{S} are known.*

30 **A2:** *The interleaved code symbol estimates of the interfering users $\hat{\mathbf{x}}_k^{(n)}$ which is a vector containing all the signal estimates at iteration n for all users except user k , coming out of said corresponding signal processing*

component 2 can be modelled as $\hat{x}_k^{(n)} = x_k + \hat{v}_k^{(n)}$ where x_k is the transmitted symbol for user k and $\hat{v}_k^{(n)}$ is the corresponding estimated noise sample which is uncorrelated with \mathbf{x} , which is a vector containing the transmitted symbols for all users, and also uncorrelated over time and iterations, but not over users at a given iteration, that is $\langle \mathbf{x}, \hat{v}_k^{(n)} \rangle = 0, \langle \hat{v}_k^{(n)}, \hat{v}_k^{(m)} \rangle = 0$ for $n \neq m$, where n and m denote different iteration numbers, and the estimated noise correlation for user k and j at iteration n is defined as $\langle \hat{v}_k^{(n)}, \hat{v}_j^{(n)} \rangle = q_{kj}$.

Define the estimated noise covariance matrix $\mathbf{Q}_k^{(n)} = \langle \hat{v}_k^{(n)}, \hat{v}_k^{(n)} \rangle$, with elements determined as shown above.

10 Let $\mathbf{c}_k^{(n)}$ be the auxiliary vector that contains all signals received from user k at iteration n and all previous iterations, according to the following recursively defined vector of observables as input to the said linear iterative filter denoted by $\Lambda_k^{(n)}$,

$$\mathbf{c}_k^{(n)} = \begin{cases} \mathbf{r} & n = 1 \\ \begin{pmatrix} \mathbf{c}_k^{(n-1)} \\ \hat{\mathbf{x}}_k^{(n-1)} \end{pmatrix} & n = 2, 3, \dots \end{cases}$$

15 Under A1 and A2, the linear minimum mean square error estimate of said signal x_k given said signal $\mathbf{c}_k^{(n)}$ is given by the output $\tilde{x}_k^{(n)}$ of the recursive filter which is an updated estimate of the transmitted signal for user k at iteration n , defined as follows.

$$\begin{aligned} \tilde{x}_k^{(n)} &= \tilde{x}_k^{(n-1)} + \mathbf{m}_k^{(n)} (\hat{\mathbf{x}}_k^{(n-1)} - \tilde{\mathbf{x}}_k^{(n-1)}) \\ \tilde{\mathbf{x}}_k^{(n)} &= \tilde{\mathbf{x}}_k^{(n-1)} + \mathbf{M}_k^{(n)} (\hat{\mathbf{x}}_k^{(n-1)} - \tilde{\mathbf{x}}_k^{(n-1)}) \\ \mathbf{m}_k^{(n)} &= -\mathbf{w}_k^{(n)} (\mathbf{I} + \mathbf{Q}_k^{(n-1)} - \mathbf{W}_k^{(n)})^{-1} \\ \mathbf{M}_k^{(n)} &= (\mathbf{I} - \mathbf{W}_k^{(n)}) (\mathbf{I} + \mathbf{Q}_k^{(n-1)} - \mathbf{W}_k^{(n)})^{-1} \end{aligned}$$

where for user k at iteration n $\mathbf{m}_k^{(n)}$ is the said first linear iterative filter, $\mathbf{M}_k^{(n)}$ is the said second linear iterative filter, \mathbf{I} is an identity matrix with ones on the diagonal and zeros everywhere else, $\mathbf{w}_k^{(n)}$ is a recursive, complex auxiliary

25

vector and $\mathbf{W}_k^{(n)}$ is a first recursive, complex auxiliary matrix, respectively, the recursive update equations for $n = 3, 4, \dots$ are as follows:

$$\begin{aligned} \mathbf{w}_k^{(n)} &= \mathbf{w}_k^{(n-1)} \left[\mathbf{I} - \left(\mathbf{H}_k^{(n-1)} \right)^{-1} \left(\mathbf{I} - \mathbf{W}_k^{(n-1)} \right) \right]^{-1} \\ \mathbf{W}_k^{(n)} &= \mathbf{W}_k^{(n-1)} + \left(\mathbf{I} - \mathbf{W}_k^{(n-1)} \right) \left(\mathbf{H}_k^{(n-1)} \right)^{-1} \left(\mathbf{I} - \mathbf{W}_k^{(n-1)} \right) \\ \mathbf{H}_k^{(n-1)} &= \mathbf{I} + \mathbf{Q}_k^{(n-2)} - \mathbf{W}_k^{(n-1)} \end{aligned}$$

5

where $\mathbf{H}_k^{(n-1)}$ is a second recursive, complex auxiliary matrix. The initial

conditions with $\tilde{\mathbf{x}}_k^{(0)} = 0$ and $\mathbf{x}_k^{(0)} = 0$ are $\mathbf{m}_k^{(1)} = \mathbf{s}_k^t (\mathbf{S}\mathbf{S}^t + \sigma^2 \mathbf{I})^{-1}$,

$\mathbf{M}_k^{(1)} = \mathbf{S}_k^t (\mathbf{S}\mathbf{S}^t + \sigma^2 \mathbf{I})^{-1}$ for $n=1$ and $\mathbf{w}_k^{(2)} = \mathbf{s}_k^t (\mathbf{S}\mathbf{S}^t + \mathbf{I})^{-1} \mathbf{S}_k^-$, $\mathbf{W}_k^{(2)} = \mathbf{S}_k^t (\mathbf{S}\mathbf{S}^t + \sigma^2 \mathbf{I})^{-1} \mathbf{S}_k^-$

for $n=2$, where \mathbf{s}_k is the linear constraint for user k , \mathbf{s}_k^t denotes the complex conjugate transpose of said vector \mathbf{s}_k , \mathbf{S}_k^- is the constraint matrix with column k deleted and \mathbf{S}_k^- denotes the complex conjugate transpose of vector \mathbf{S}_k^- .

10

4. A method of communicating in a multiple access network by iteratively receiving multi user signals the method comprising the steps of:

15

determining a first set of signal estimates for the multi user signals based on linear channel constraints;

determining a second set of signal estimates based on non-linear channel constraints and the first set of signal estimates;

20

providing the second set of signal estimates as input to the step of determining the first set of signal estimates;

repeating the above steps at least once.

5. An iterative receiver for receiving multi user signals comprising:

25

a first signal processing component for determining a first set of signal estimates for the multi user signals based on linear channel constraints;

a second signal processing component for receiving the first set of signal estimates and determining a second set of signal estimates based on non-linear channel constraints;

wherein the signal processing components are operatively connected so as to provide the second set of signal estimates as input to the first signal processing component in a succeeding iteration cycle.

- 5 6. A method of communicating in a multiple access network by iteratively receiving OFDM packets the method comprising the following steps:
- a) sample a receiver input signal consisting of signals from one or more antenna;
 - b) add the input signal with one of a plurality of prior stored received
10 packet sample estimates to determine a packet sample hypothesis;
 - c) determine an information bit estimate from the sample hypothesis for storage in an information bit estimates list;
 - d) determine an updated received packet sample estimate from the sample hypothesis for updating the plurality of prior stored estimates;
 - 15 e) subtract the updated sample estimate from the sample hypothesis to determine a noise hypothesis and provide the noise hypothesis as the receiver input signal;
 - f) repeat steps a) to e) until at least one or more complete packets are accumulated in the information bit estimates list.
- 20
7. A method of communicating in a multiple access network by iteratively providing a sample estimates list in an OFDM receiver, the method comprising the steps of:
- a) sample a receiver input signal;
 - 25 b) determine a packet sample estimate from the sampled receiver input signal;
 - c) store the packet sample estimate;
 - d) determine a packet sample hypothesis by adding the receiver input with a selected previously stored packet sample estimate;
 - 30 e) determine an updated packet sample estimate by decoding and re-transmission modelling the packet sample hypothesis;
 - f) update the selected previously stored packet sample estimate with the updated packet sample estimate.

8. A method of communicating in a multiple access network by iteratively providing a packet information bit estimates list in an OFDM receiver the method comprising the steps of:
- 5 a) determine a packet sample hypothesis by adding a receiver input with a selected previously stored packet sample estimate;
 - b) determine an information bit estimate by decoding the packet sample hypothesis with one or more of a hard decoding technique and a soft decoding technique
 - 10 c) storing the information bit estimate with one or more previously determined information bit estimates;
 - d) repeating steps a) to c) until a complete packet is accumulated.
9. A method of communicating in a multiple access network including determining a hybrid OFDM received packet sample estimate the method comprising the step of:
- 15 multiplexing a time domain channel application received sample estimate with a frequency domain channel application received sample estimate, such that the multiplexed time domain sample estimate is mapped to correspond to one or more of:
- 20 an OFDM signal cyclic prefix;
 - an OFDM tail portion, and;
 - an OFDM guard period,
 - and wherein the multiplexed frequency domain sample estimate is mapped to correspond to one or more of:
 - 25 an OFDM signal preamble and;
 - an OFDM payload data symbol.
10. A method of communicating in an OFDM multiple access network comprising the step of:
- 30 performing multi-user interference cancelling which comprises adapting a single pass OFDM receiver to iteratively receive signals at the sampling level so as to allow the receiver to differentiate a desired packet from an observation of an interference signal at the receiver input.

11. A method of communicating in a multiple access communication network by synchronizing packets arriving at a receiver the method comprising the steps of:
- receiving a packet input signal;
 - 5 determining a correlation signal corresponding to the packet input signal;
 - processing the input and correlation signals such that at least one of the input signal and the correlation signal are filtered;
 - determining a decision statistic by combining a power component of the processed correlation signal with a power component of the processed input
 - 10 signal;
 - nominate a point in time given by a predetermined threshold condition of the decision statistic as a received packet arrival time.
12. A method according to claim 11, wherein the step of processing at least
- 15 one of the input and correlation signals is performed by one of:
- a center weighted filter having a triangular impulse response;
 - a root raised cosine filter;
 - a Hanning window filter;
 - a Hamming window filter;
 - 20 a combined Hanning/Hamming window filter.
13. A method according to claim 11 or 12, wherein the predetermined threshold condition is one of:
- the decision statistic crossing the predetermined threshold and;
 - 25 a maximum of the decision statistic occurring above the predetermined threshold.
14. A method according to claim 11, 12 or 13, wherein the step of determining the correlation signal is performed every K th sample of a sampled packet input
- 30 signal, where K is an integer greater than or equal to 1.

15. A method of communicating by tracking time varying channels in a multiple access packet based communication network the method comprising the steps of:
- a) initializing a channel estimate reference based on an initial channel estimate derived from a received packet preamble;
 - b) updating the channel estimate reference based on a packet data symbol channel estimate in a coded portion of the current and all previously received data symbols;
 - c) repeating step b) at the arrival of subsequent packet data symbols.
16. A method according to claim 15, further comprising the step of:
storing the channel estimate reference in a channel estimate data base at the receiver.
17. A method according to any one of claims 15 or 16, further comprising the step of:
transforming the packet data symbol channel estimates to the frequency domain prior to updating the stored channel estimate reference to provide a time smoothed channel estimate reference.
18. A method according to claim 15, wherein the method further comprises the steps of:
for each subsequent received data symbol within step b), pipelining the steps of demodulating and modulating, and;
updating the channel estimate reference with the further step of FEC decoding.
19. A method of communicating by estimating time varying channel impairments in a multiple access packet based communication network, where channel impairments comprise channel variation, signal frequency offset and signal time offset, the method comprising the steps of:
- a) initializing a set of channel impairment estimates based on initial pilot and preamble symbols included in a received packet;

b) performing a decoder operation which comprises processing the set of channel impairment estimates and the received packet to determine a set of transmit symbol estimates;

c) updating the set of channel impairment estimates with the
5 determined set of symbol estimates and the received packet;

d) repeating steps b) and c).

20. A method of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, the method
10 comprising the steps of:

a) estimating a frequency offset based on information included in a received packet preamble;

b) correcting a received signal using the estimated frequency offset;

c) determining a channel estimate using information included in the
15 received packet preamble;

d) transforming a sample sequence of the received signal into the frequency domain such that the sample sequence includes OFDM symbols and intervening cyclic prefixes;

e) performing a decoding operation which comprises processing the
20 determined channel estimate and received packet;

f) generating a transmission sample sequence using the decoding results and information in the received packet preamble;

g) transforming the transmission sample sequence into the frequency domain;

25 h) updating the determined channel estimate by combining the received sample sequence and the transmission sample sequence in the frequency domain;

i) repeating steps e) to h).

30 21. A method of communicating in a multiple access network by time varying channel estimation in a receiver for receiving transmitted packets, where the receiver retrieves OFDM symbols from a received signal and transforms the retrieved symbols to the frequency domain, the method comprising the steps of:

- a) determine a matrix of training symbols comprised of symbol estimates derived from a decoder;
- b) determine a matrix of frequency domain received OFDM symbols;
- c) determine an intermediate channel estimate matrix by multiplying
5 the OFDM symbol matrix by the conjugate of the training symbol matrix;
- d) determine an intermediate matrix of training weights comprising the absolute value of the training symbol matrix;
- e) perform a smoothing operation on both intermediate matrices comprising 2 dimensional filtering;
- 10 f) determine the channel estimate by dividing the smoothed channel estimate matrix with the smoothed training weight matrix.

22. A method of communicating in a multiple access network by estimating offsets in a receiver for receiving transmitted packets, the method comprising the
15 steps of:

- a) determine a matrix of frequency domain received OFDM symbols;
- b) determine a matrix of conjugated data symbols wherein the data symbols comprise one or more of preamble, training and estimated symbols;
- c) determine a 2 dimensional Fourier transform matrix comprised of
20 the received symbol matrix multiplied with the conjugated symbol matrix;
- d) filter the Fourier transform matrix;
- e) determine time and frequency offsets by locating peak power occurrences within the filtered Fourier transform.

25 23. A method of communicating in a multiple access packet communication network by synchronizing a received signal in a multi antenna receiver the method comprising:

- correlating a received signal observation at each of a plurality of antennae with a known signal preamble to provide a received signal sequence;
- 30 determine a power signal of each received signal sequence;
- combine the determined power signals in accordance with a time averaged weighting based on estimated antenna signal strength for each antenna;

determine a time of arrival for the received signal in accordance with a predetermined threshold condition.

24. A method according to claim 33, further comprising the steps of:
- 5 determining an estimate of the relative phase and amplitude coefficients of a receiving channel for each antenna;
- combining a received signal with the estimated coefficients to provide a composite signal;
- 10 determining a time of arrival of the received signal by correlating the composite signal with a delayed version of itself.
25. Apparatus adapted to communicate in a multiple access communication network, said apparatus comprising:
- 15 processor means adapted to operate in accordance with a predetermined instruction set,
- said apparatus, in conjunction with said instruction set, being adapted to perform a method according to any one of claims 4, 6 to 24.
26. A computer program product comprising:
- 20 a computer usable medium having computer readable program code and computer readable system code embodied on said medium for communicating in a multiple access communication network, said computer program product comprising:
- 25 computer readable code within said computer usable medium for performing the method steps according to any one of claims 4, 6 to 24.
27. A method substantially as herein described with reference to the accompanying drawings.
- 30 28. Apparatus substantially as herein described with reference to the accompanying drawings.

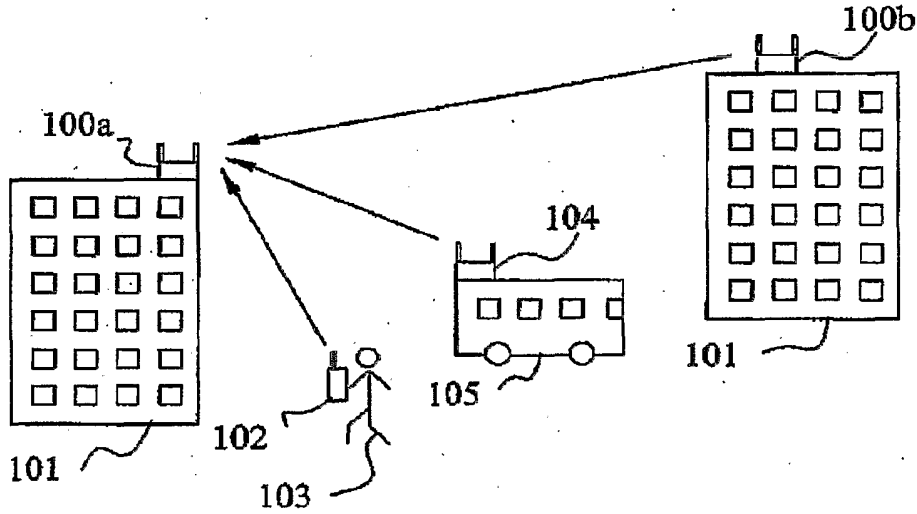


Figure 1

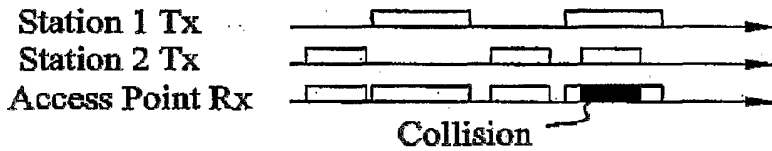


Figure 2 (Related Art)

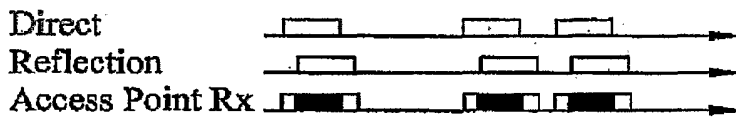


Figure 3 (Related Art)

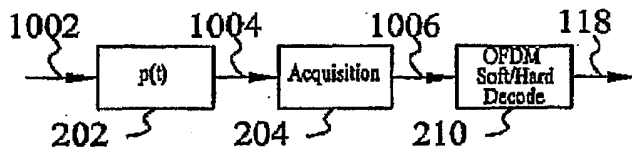
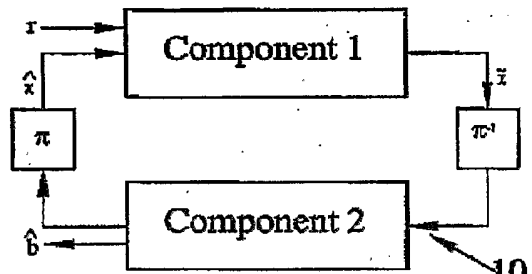
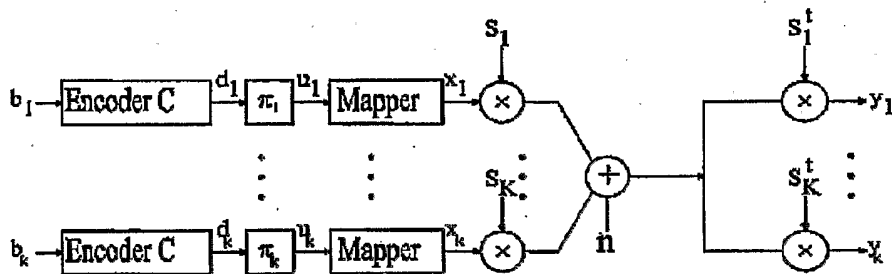


Figure 10 (Related Art)

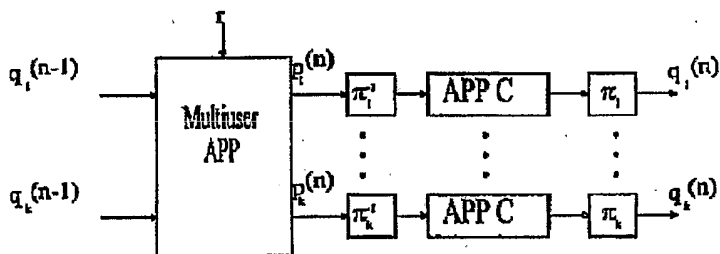
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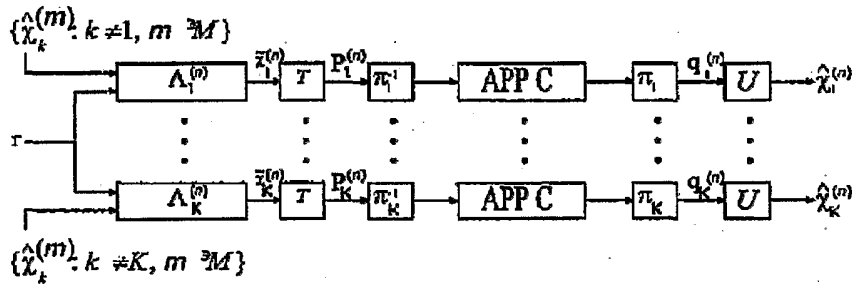
Generic iterative receiver structure
Figure 4



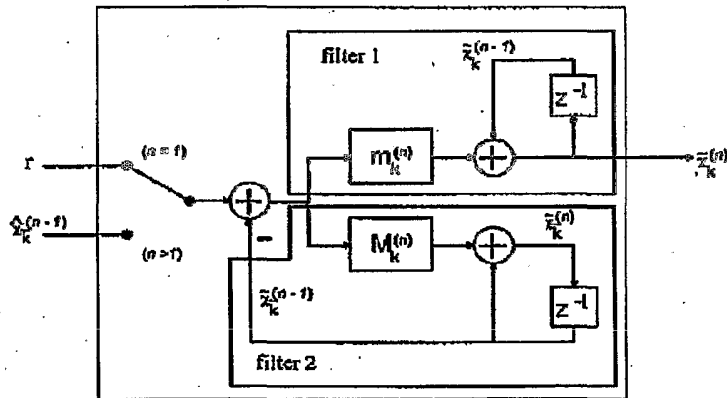
The transmission system model for coded CDMA
Figure 5



Canonical iterative multiuser decoder
Figure 6



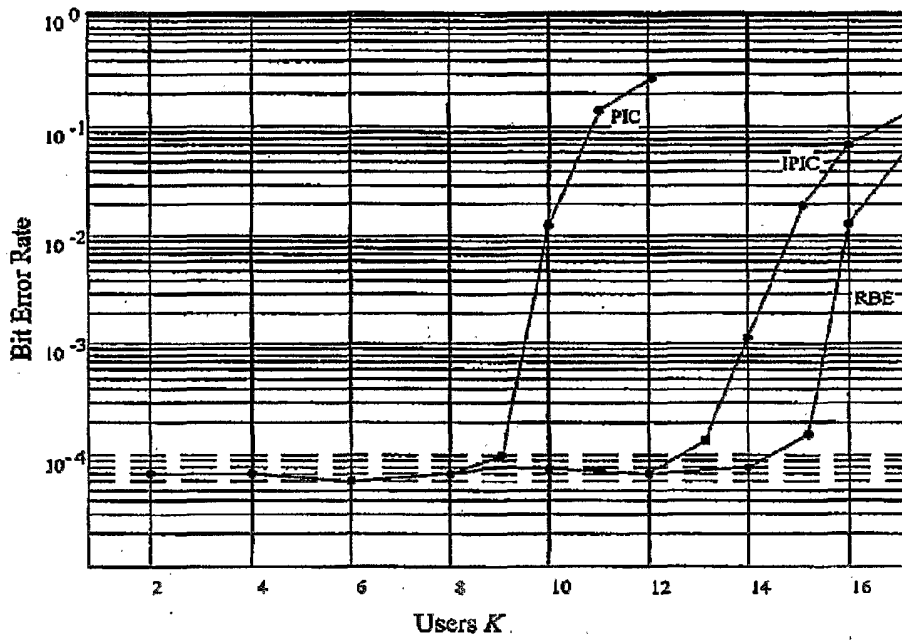
Iterative multiuser decoder with linear multiuser estimation
Figure 7



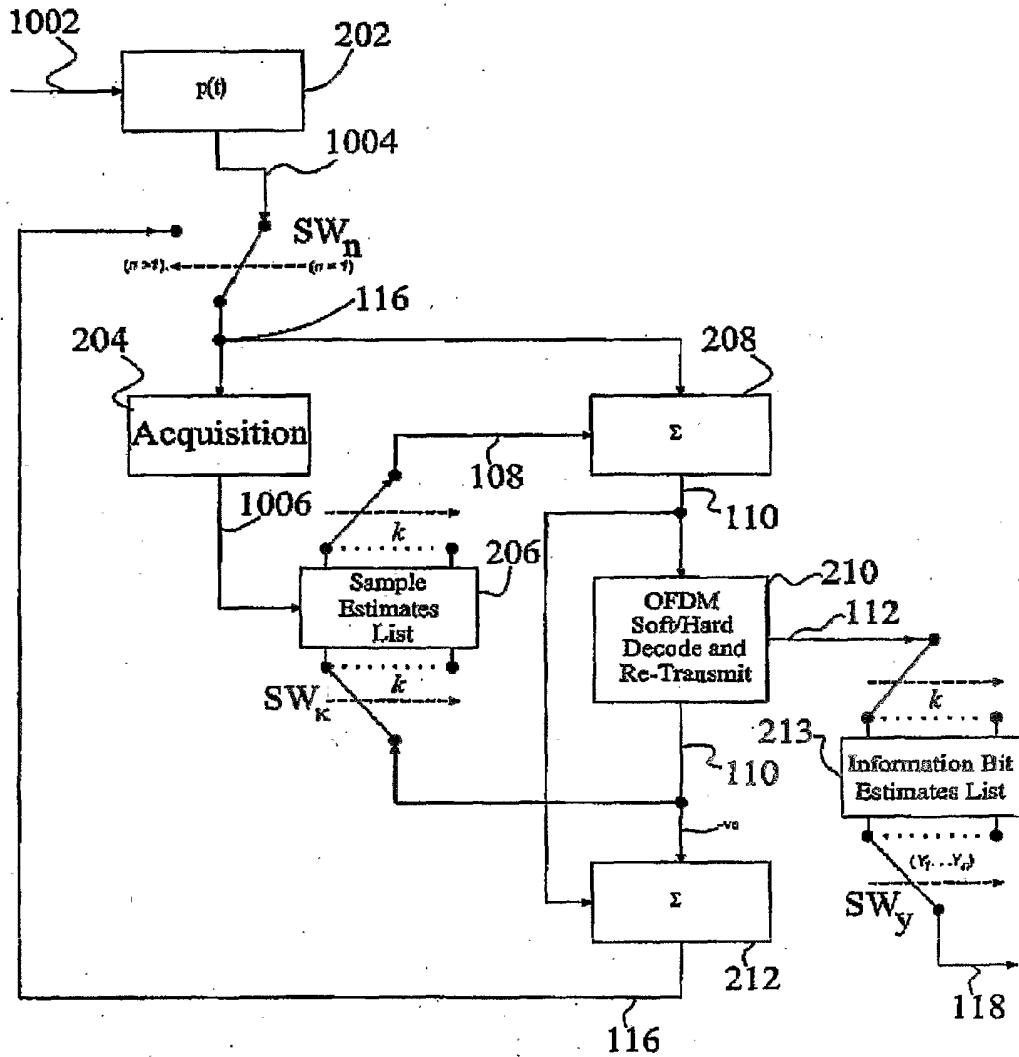
The recursive filter $\Lambda_k^{(n)}$ For $(n = 1)$ the input signal is r while for $n \geq 2$ the input signal is $\hat{x}_k^{(n-1)}$

Figure 8

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BER versus users after 10 iterations, $N = 8$, $E_b/N_0 = 5$ dB
Figure 9



Iterative Interference Canceling Receiver Structure

Figure 11

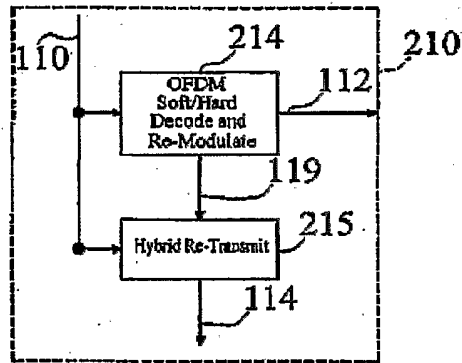


Figure 12

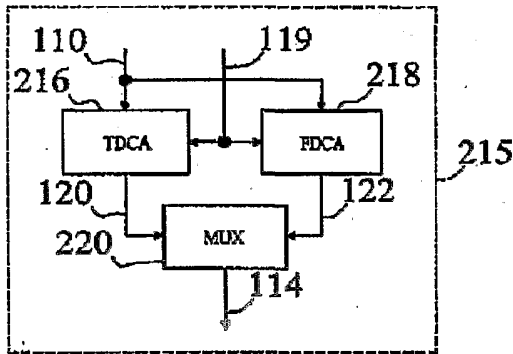


Figure 13

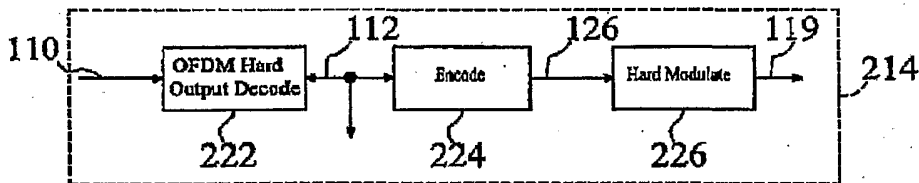


Figure 14

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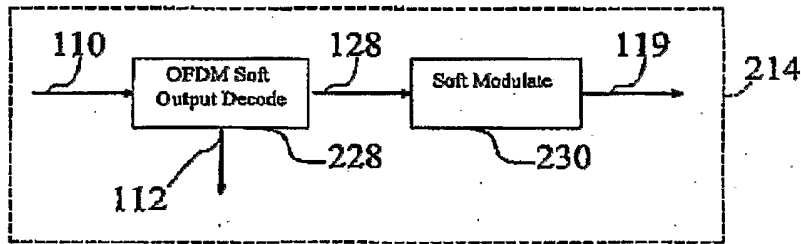


Figure 15

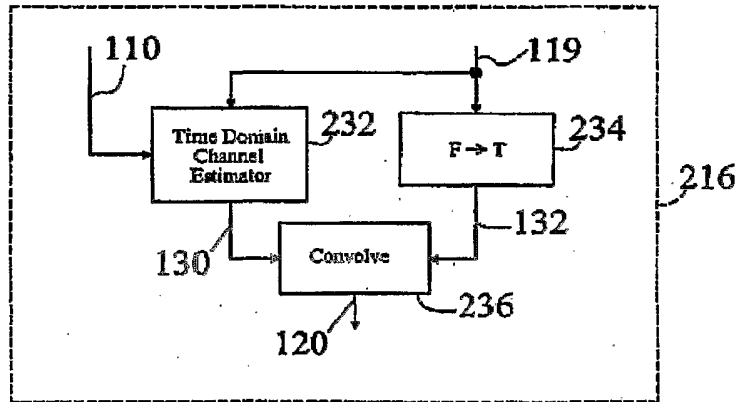


Figure 16

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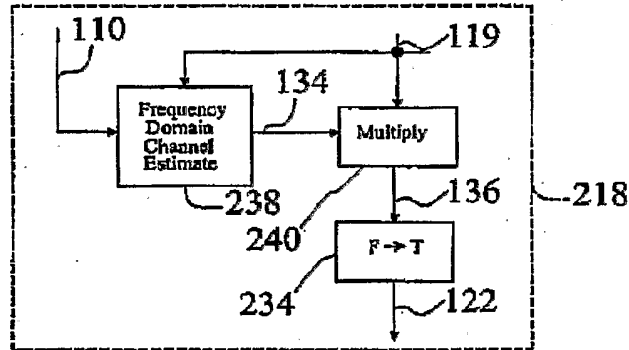


Figure 17

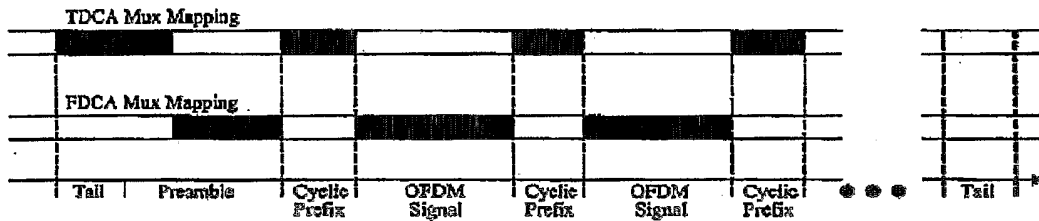


Figure 18

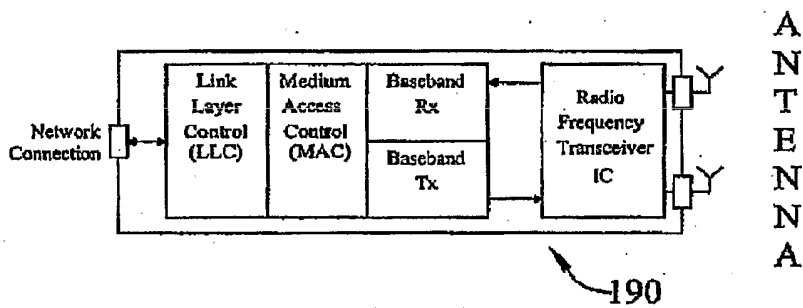


Figure 19a

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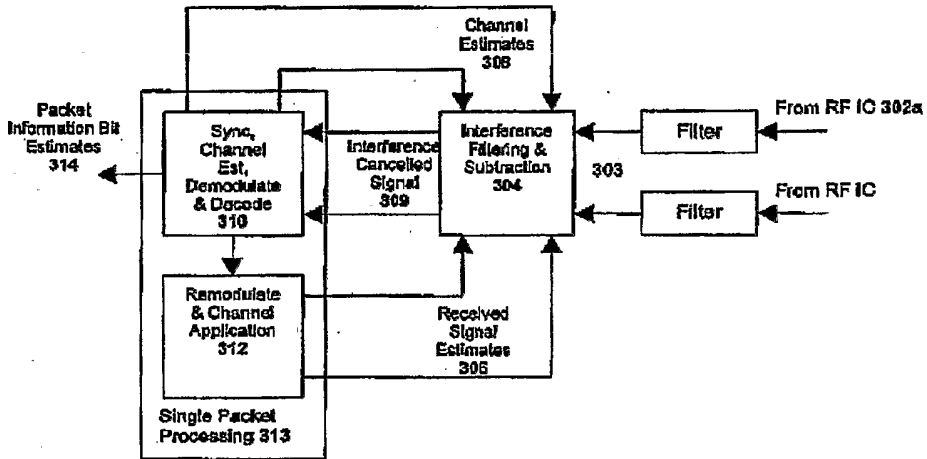


Figure 19b

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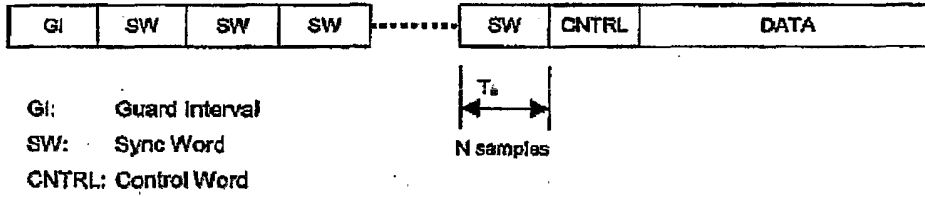


Figure 20

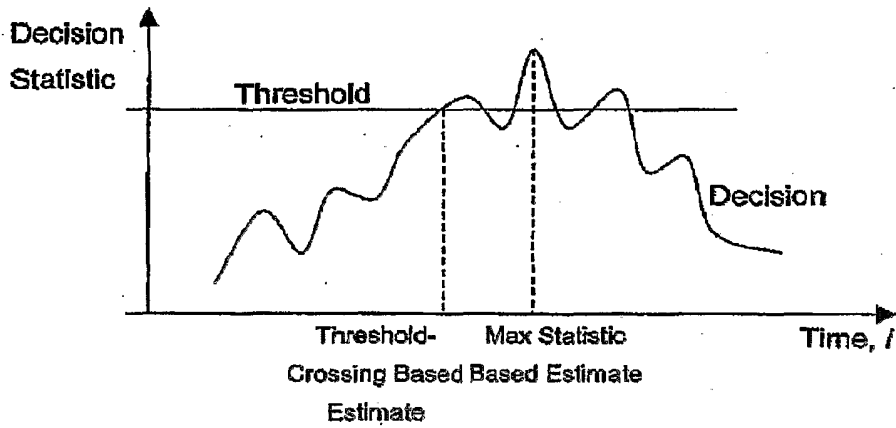


Figure 21

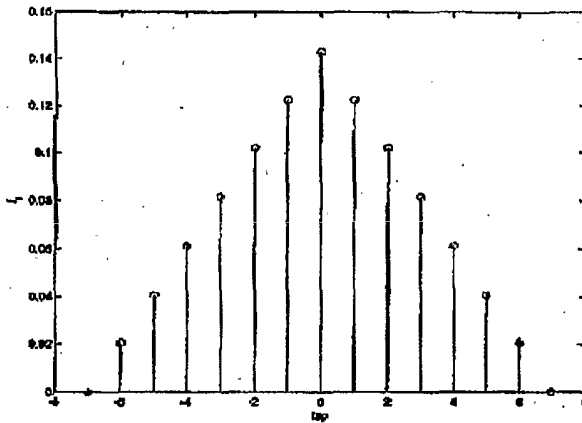


Figure 22

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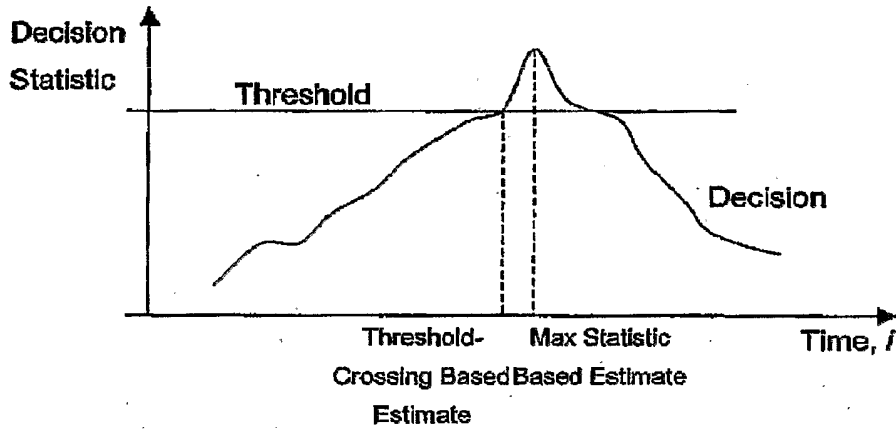


Figure 23

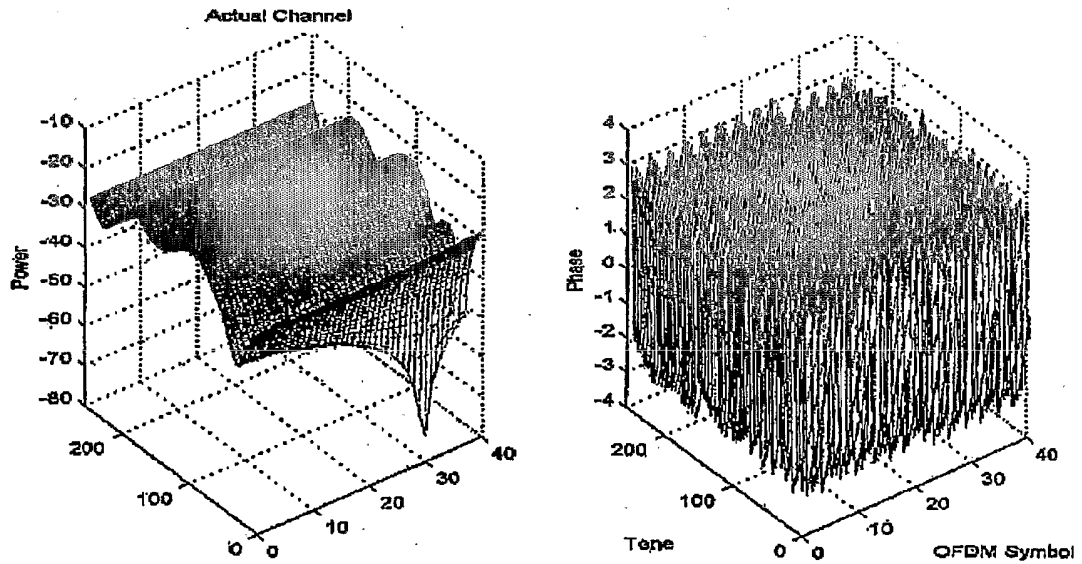


Figure 24

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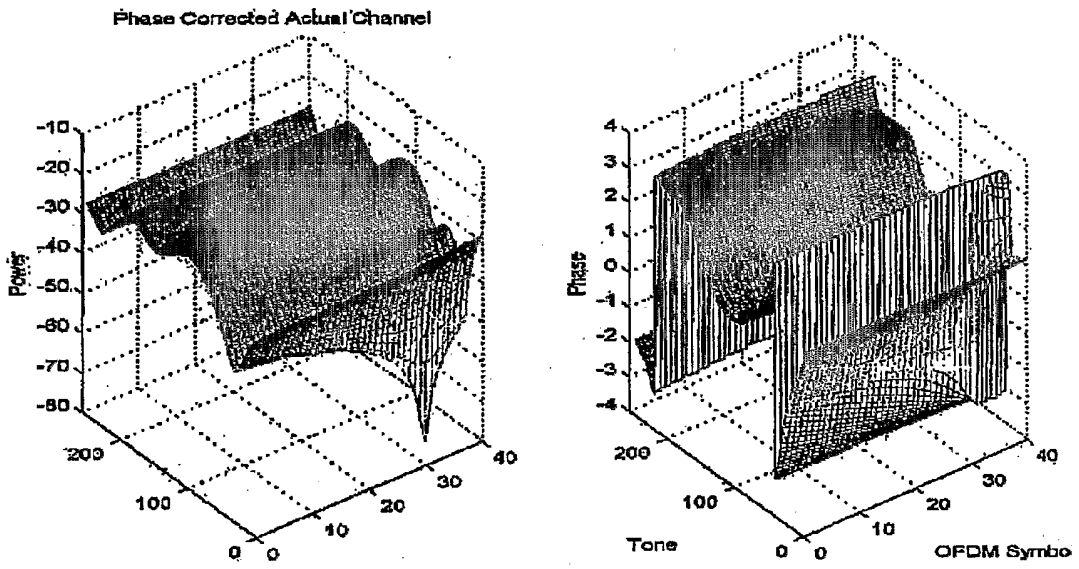


Figure 25

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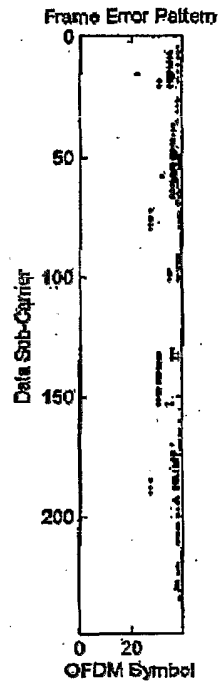


Figure 26

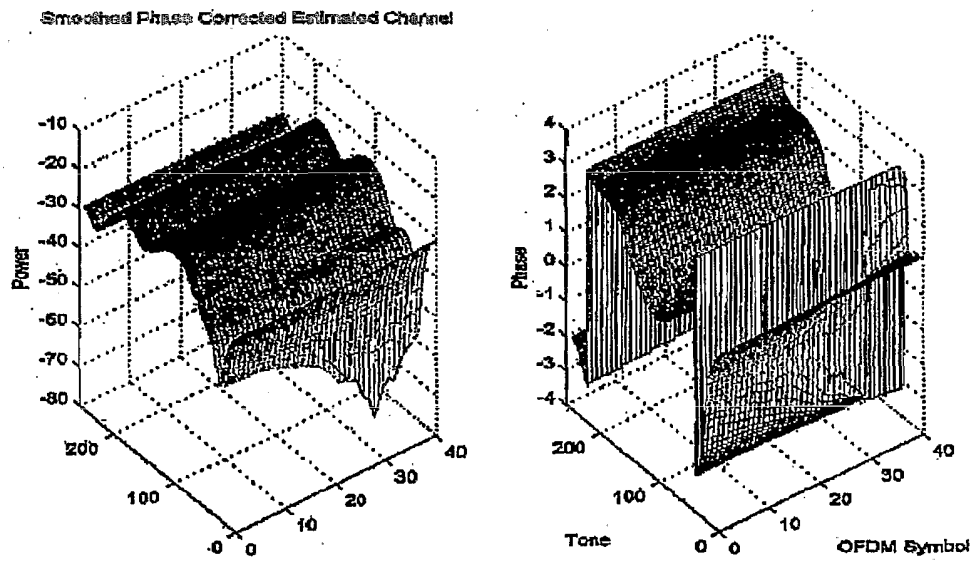


Figure 27

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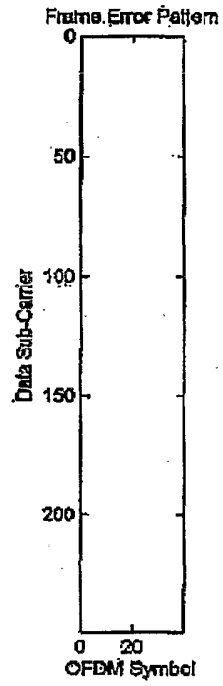


Figure 28

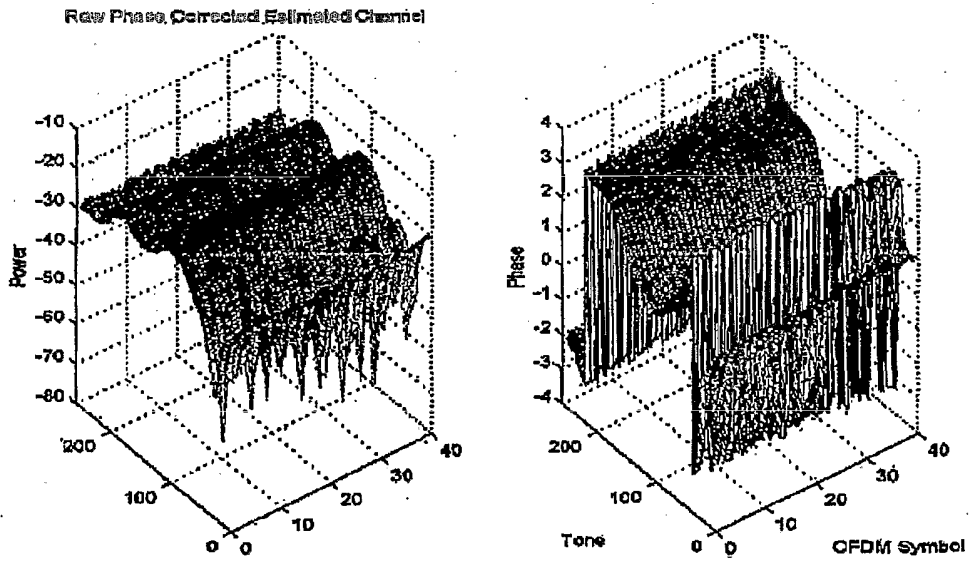


Figure 29

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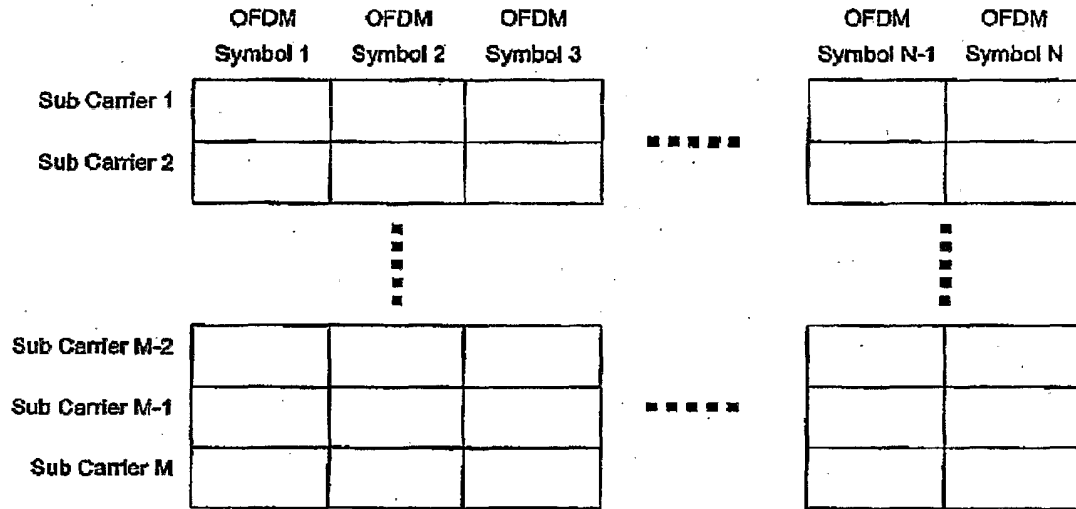


Figure 31

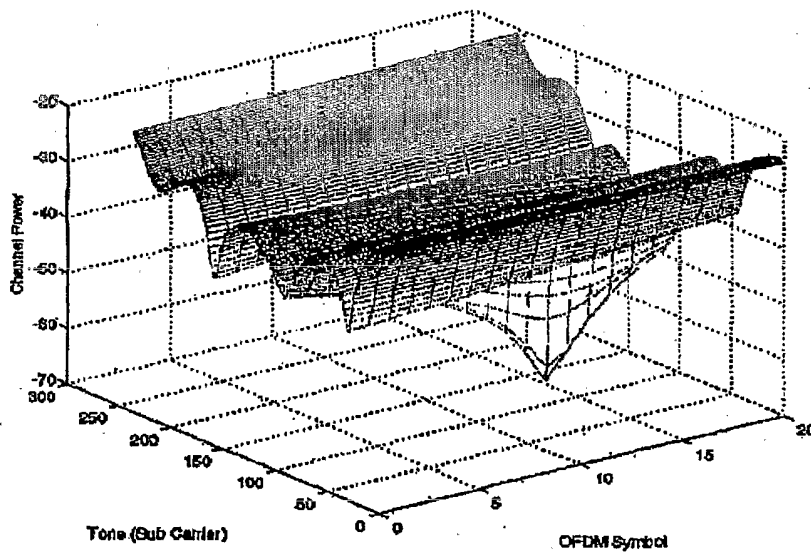


Figure 32

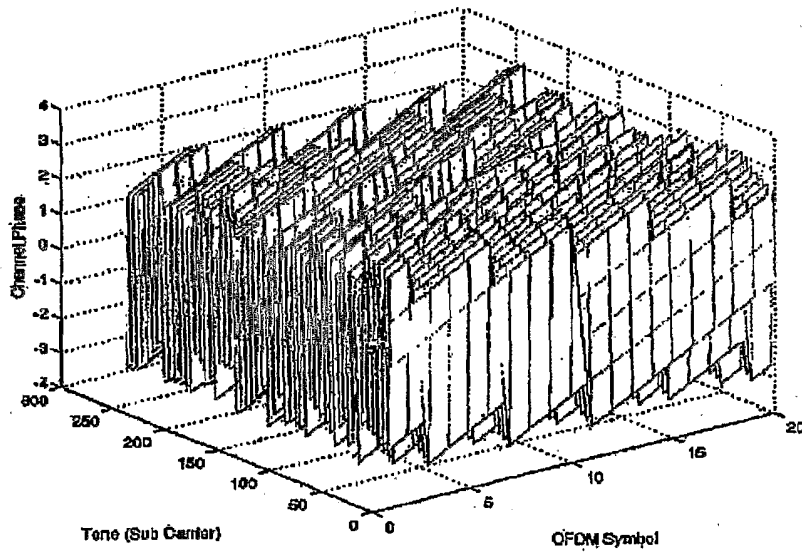


Figure 33

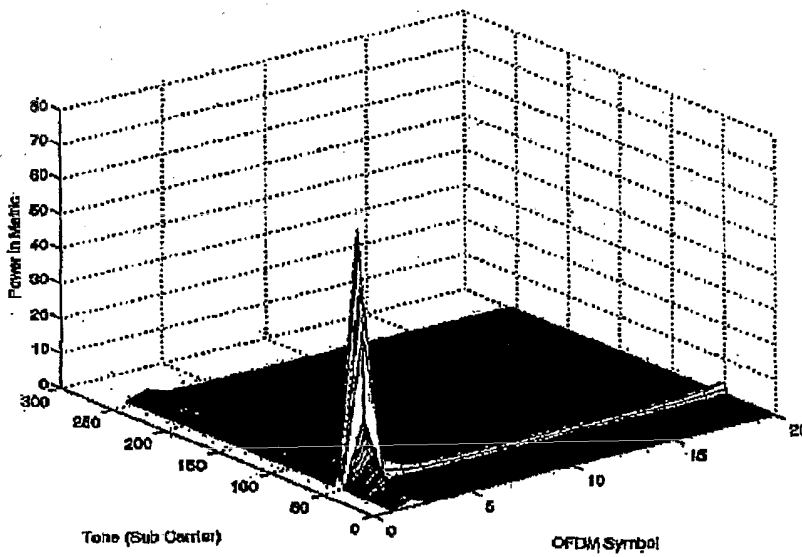


Figure 34

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2004/001036

<p>A. CLASSIFICATION OF SUBJECT MATTER</p> <p>Int. Cl. ⁷: H03M 13/00, H04L 27/26, H04B 7/208</p> <p>According to International Patent Classification (IPC) or to both national classification and IPC</p>																	
<p>B. FIELDS SEARCHED</p> <p>Minimum documentation searched (classification system followed by classification symbols)</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) See Supplemental Box</p>																	
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="width:10%;">Category*</th> <th style="width:70%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width:20%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td align="center">P,X</td> <td>WO 2003/094037 A1 (UNIVERSITY OF SOUTH AUSTRALIA ET AL) 13 November 2003 whole document</td> <td align="center">1-3</td> </tr> <tr> <td align="center">P,A</td> <td>US 2003/0185284 A1 (YOUSEF ET AL) 2 October 2003 whole document</td> <td align="center">15-18</td> </tr> <tr> <td align="center">X</td> <td>Rasmussen et al : "Recursive Filters for Iterative Multiuser Decoding" ISIT 2002, Lausanne, Switzerland June 30-July 5 , 2002 page 445</td> <td align="center">1-3</td> </tr> <tr> <td align="center">A</td> <td>WO 2001/058105 A1 (AT&T CORP) whole document</td> <td align="center">1-5,10,15-18</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	P,X	WO 2003/094037 A1 (UNIVERSITY OF SOUTH AUSTRALIA ET AL) 13 November 2003 whole document	1-3	P,A	US 2003/0185284 A1 (YOUSEF ET AL) 2 October 2003 whole document	15-18	X	Rasmussen et al : "Recursive Filters for Iterative Multiuser Decoding" ISIT 2002, Lausanne, Switzerland June 30-July 5 , 2002 page 445	1-3	A	WO 2001/058105 A1 (AT&T CORP) whole document	1-5,10,15-18
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.															
P,X	WO 2003/094037 A1 (UNIVERSITY OF SOUTH AUSTRALIA ET AL) 13 November 2003 whole document	1-3															
P,A	US 2003/0185284 A1 (YOUSEF ET AL) 2 October 2003 whole document	15-18															
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A	WO 2001/058105 A1 (AT&T CORP) whole document	1-5,10,15-18															
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex																	
<p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>																
<p>Date of the actual completion of the international search 10 November 2004</p>	<p>Date of mailing of the international search report 22 NOV 2004</p>																
<p>Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929</p>	<p>Authorized officer JAMES WILLIAMS Telephone No : (02) 6283 2599</p>																

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2004/001036

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2002/039597 A2 (QUALCOMM Incorporated) 16 May 2002 whole document especially page 9	10
P,A	US 2004/0062299 A1 (MCDONOUGH ET AL) 1 April 2004 whole document	6-8
P,A	US 2004/0062297 A1 (MCDONOUGH ET AL) 1 April 2004 whole document	6-8
A	US 2002/0031170 A1 (YOON) 14 March 2002 whole document	6-8
X A	US 2003/0112825 A1 (WANG ET AL) 19 June 2003 whole document	19 20
X A	AU 200038414 B2 (NIPPON TELEGRAPH AND TELEPHONE CORPORATION) 10 November 2000 whole document	19 20

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2004/001036

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See Supplemental Box

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
Claims 1-5,10,15-18
Claims 6-8
Claims 19-20
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2004/001036

Supplemental Box

(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: B

Group 1 Claims 1-5,10 and 15-18

WPAT: MULTI+ OR +DMA ,(ITERATIVE OR RECURSIVE) ,ESTIMAT+ , SIGNAL

Group 2 Claims 6-8

WPAT: OFDM OR ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING, (SAMPLE? OR PART? OR SELECTION?), PACKET?, SAMPLE ,HYPOTHESIS

Group 3 Claims 19-20

WPAT: MULTIPLE ACCESS OR +DMA OR OFDM ,PACKET? , (CHANNEL OR TIME OR FREQUENCY) , (VARIA+ OR OFFSET? OR IMPAIRMENT)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2004/001036

Supplemental Box

(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III

Group 1: Claims 1-5,10 and 15-18 method of communicating and decoding using iterative estimates

Group 2: Claims 6-8 method of communication with packet sample hypothesis

Group 3: Claim 9 method of communications with multiple time domain and frequency domain samples

Group 4: Claims 11-14 method of communicating by synchronising packets using input /output correlation

Group 5: Claims 19-20 method of communicating using estimating time varying channel impairments

Group 6: Claims 21-22 method of communicating using a training symbol matrix

Group 7: Claim 23 multi-antenna synchronising using received power

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2004/001036

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
WO	03094037				
US	2003185284				
WO	01058105				
US	2004062299				
US	2004062297	JP	2004289788		
US	2003031170				
US	2003112825	US	2003058951	US	2003058968
		WO		WO	03028205
AU	38414/00	CA	2346714	EP	1172956
		WO	0065756	JP	2001313624
WO	0239597	AU	27299/02	EP	1336255
				US	6788733
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.					
END OF ANNEX					

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	12303947
	Filing Date	2010-07-07
	First Named Inventor	Yeong Hyeon Kwon
	Art Unit	2478
	Examiner Name	KHAJURIA, SHRIPAL K
	Attorney Docket Number	2101-3596

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ² j	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1	2005/011128	WO		2005-02-03	COHDA WIRELESS PTY LTD		<input type="checkbox"/>
	2	2006/015108	WO		2006-02-09	ZTE SAN DIEGO, INC		<input type="checkbox"/>

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		12303947
	Filing Date		2010-07-07
	First Named Inventor	Yeong Hyeon Kwon	
	Art Unit	2478	
	Examiner Name	KHAJURIA, SHRIPAL K	
	Attorney Docket Number	2101-3596	

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, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1		<input type="checkbox"/>

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EXAMINER SIGNATURE

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

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	KHAJURIA, SHRIPAL K
Attorney Docket Number	2101-3596

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

- See attached certification statement.
- The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.
- A certification statement is not submitted herewith.

SIGNATURE

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	/Harry Lee/	Date (YYYY-MM-DD)	2011-10-31
Name/Print	Harry Lee	Registration Number	56,814

This collection of information is required by 37 CFR 1.97 and 1.98. 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 1 hour 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.**

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 the Freedom of Information Act requires disclosure of these records.
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 inspections 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.

AMENDMENTS TO THE CLAIMS

Please amend the claims as follows:

1-30. (Canceled)

31. (Currently Amended) A method of transmitting a preamble sequence in a mobile communication system, the method comprising:

~~generating said preamble sequence by repeating a specific sequence at least one time and concatenating a cyclic prefix (CP) to a front end of said repeated sequence, said CP being identical to a part of a rear end of said specific sequence; and~~

repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L);

generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence; and

transmitting, on a random access channel, said preamble sequence to a receiving side ~~on a random access channel.~~

32. (Currently Amended) The method of claim 31, further comprising generating said specific sequence from a Constant Amplitude Zero Auto Correlation (CAZAC)~~(Constant Amplitude Zero Auto Correlation)~~ sequence.

33. (Currently Amended) The method of claim 32, further comprising applying a cyclic shift to said specific sequence generated from said CAZAC sequence.

34. (Currently Amended) The method of claim 33, wherein a value of said applied cyclic shift is determined as an integer ~~value~~ multiple of a predetermined circular shift unit.

35. (Previously Presented) The method of claim 33, wherein a value of said applied cyclic shift is used as additional information.

36. (Previously Presented) The method of claim 33, wherein applying said cyclic shift comprises multiplying said specific sequence by an exponential sequence.

37. (Currently Amended) The method of claim 31, further comprising generating said specific sequence by combining at least two code sequences mapped with at least one information bit, ~~respectively~~.

38. (Currently Amended) A transmitter for transmitting a preamble sequence in a mobile communication system, the transmitter comprising:

a preamble generation unit configured to generate said preamble sequence by repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L) and concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence;

~~means for generating said preamble sequence by repeating a specific sequence at least one time and concatenating a cyclic prefix (CP) to a front end of said repeated sequence, said cyclic prefix being identical to a rear end of said specific sequence; and~~

~~means for transmitting a transmission unit configured to transmit, on a random access channel, said preamble sequence to a receiving side on a random access channel.~~

39. (Currently Amended) The transmitter of claim 38, wherein ~~said means for generating said preamble are~~ said preamble generation unit is further configured to generate said specific sequence from a Constant Amplitude Zero Auto Correlation (CAZAC) ~~(Constant Amplitude Zero Auto Correlation)~~ sequence.

40. (Currently Amended) The transmitter of claim 39, wherein said preamble generation unit ~~said means for generating said preamble are~~ is further configured to apply a cyclic shift to said specific sequence generated from said CAZAC sequence.

41. (Currently Amended) The transmitter of claim 40, wherein a value of said applied cyclic shift is determined as an integer ~~value~~ multiple of a predetermined circular shift unit.

42. (Currently Amended) The transmitter of ~~claim 39~~ claim 40, wherein a value of said applied cyclic shift is used as additional information.

43. (Currently Amended) The transmitter of ~~claim 39~~ claim 40, wherein said preamble generation unit ~~means for generating said preamble are~~ is further configured to apply a cyclic ~~shift~~ said cyclic shift by multiplying said specific sequence by an exponential sequence.

44. (Currently Amended) The transmitter of claim 38, wherein said preamble generation unit ~~means for generating said preamble are~~ is further configured to generate said specific sequence by combining at least two code sequences mapped with at least one information bit, ~~respectively~~.

45. (New) The method of claim 31, wherein:
said consecutive sequence comprises at least a first sequence, a second sequence, and an N-th sequence; and
said CP is identical to a rear part of said N-th sequence.

46. (New) The transmitter of claim 38, wherein:
said consecutive sequence comprises at least a first sequence, a second sequence, and an N-th sequence; and
said CP is identical to a rear part of said N-th sequence.

REMARKS

Claims 31-46 are pending in the application. Claims 31-34 and 37-44 are currently amended. Claims 45 and 46 are newly submitted. No new matter has been added as the amendments and newly submitted claims have support in the specification as originally filed. It is submitted that the application, as amended, is in condition for allowance. Reconsideration is respectfully requested.

Applicant notes with appreciation the Examiner's acknowledgement of Applicant's claim for foreign priority under 35 USC 119(a)-(d) and that all certified copies of the priority documents have been received.

Claims 31-44 are rejected under 35 U.S.C. 102(b) as being anticipated by Jung et al. (US 2006/0153282). Applicant respectfully traverses these rejections, and requests reconsideration and allowance of the pending claims in view of the following arguments.

As amended, independent claim 31 recites repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L) and generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence.

Page 2 of the Office Action states that paragraphs 0064 and 0068 of Jung disclose generating said preamble sequence by repeating a specific sequence at least one time and concatenating a cyclic prefix (CP) to a front end of said repeated sequence. Applicant provides the following remarks.

A review of cited paragraph 0064 of Jung reveals that Jung arguably discloses repeatedly transmitting a second preamble sequence. Furthermore, cited paragraph 0064 of Jung discloses that a combination of second preamble sequences is transmitted through, for example, odd and even frames. Accordingly, Jung discloses that the second preamble sequence is repeated through separate frames, such as, odd and even frames (Jung, paragraph 0064). Applicant submits that repeating a preamble via separate frames, each of which including an individual cyclic prefix and first preamble sequences, is patentably distinguishable from repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L), as

recited in independent claim 31. More specifically, since the second preamble sequence of Jung is repeated in different frames, the second preamble sequence of Jung is not a consecutive sequence as required by independent claim 31. Therefore, since Jung fails to disclose generating a consecutive sequence by repeating a specific sequence, Jung cannot teach or suggest “repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L),” as recited in independent claim 31.

Furthermore, cited paragraph 0068 of Jung discloses that “the guard interval signal is inserted using a cyclic prefix scheme in which the last predetermined samples of a time domain OFDM symbol are copied and inserted into an effective OFDM symbol or a cyclic postfix scheme in which the first predetermined samples of a time domain OFDM symbol are copied and inserted into an effective OFDM symbol.”

A review of cited paragraph 0068 of Jung reveals that an OFDM symbol or a cyclic postfix scheme are copied and inserted into an effective OFDM symbol. Similar to the arguments presented above with regard to cited paragraph 0064 of Jung, Applicant submits that although paragraph 0068 of Jung arguably discloses copying and inserting OFDM symbols into an effective OFDM symbol, paragraph 068 of Jung fails to disclose generating a consecutive sequence by repeating a specific sequence, as required by independent claim 31.

Furthermore, Applicant has reviewed Jung and has found no discussion with regard to “generating said preamble sequence by concatenating a single cyclic prefix to a front end of said consecutive sequence,” as recited in independent claim 31. Rather, a review of FIG. 2 of Jung reveals that a preamble sequence of Jung may include more than one cyclic prefix. Therefore, Applicant submits that Jung cannot teach or suggest generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence, as recited in independent claim 31.

To assist the Examiner in understanding the Applicant’s position with regard to Jung, Applicant provides below relevant portions of FIG. 2 of Jung, which has been annotated in accordance with Applicant’s position.

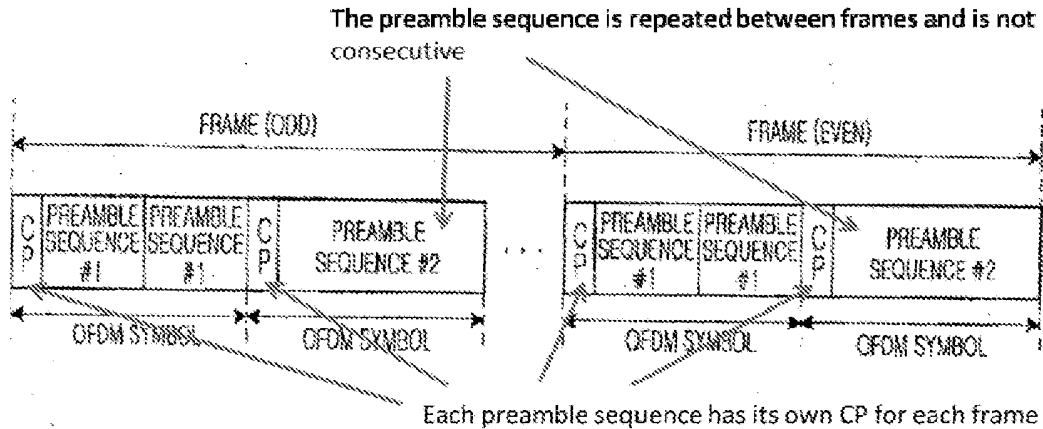


FIG.2

As illustrated in annotated FIG. 2 of Jung, the preamble sequences do not form a consecutive sequence, rather, the preamble sequences are repeated in different frames. For example, the preamble sequence #2 is split between two frames, and therefore, since the preamble sequence #2 is split between two frames, the preamble sequence #2 is not a consecutive sequence. Accordingly, as previously discussed, Jung cannot teach or suggest “repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L),” as recited in independent claim 31.

Furthermore, as illustrated in annotated FIG. 2, each of the frames, even and odd, has its own CP. Therefore, since each frame has its own CP, the preamble sequences of Jung are not concatenated with a single CP to a front end of the consecutive sequence, as required in independent claim 31. In other words, each preamble sequence of Jung has its own CP, as opposed to a single CP concatenated to a front end of the consecutive sequence to generate a preamble symbol. Therefore, as previously discussed, since Jung does not disclose concatenating a single CP to a front end of the consecutive sequence to generate a preamble symbol, Jung cannot teach or suggest “generating said preamble sequence by concatenating a single cyclic prefix (CP) to a front end of said consecutive sequence,” as recited in independent claim 31.

Furthermore, FIG. 2 of Jung arguably illustrates a consecutive “preamble sequence #1.” However, Applicant submits that the consecutive “preamble sequence #1,” as illustrated in FIG. 2 of Jung is entirely different from the “consecutive sequence” required in independent claim 31.

Specifically, paragraph 0041 of Jung discloses that “the preamble sequence transmitted through the first transmit antenna is referred to as the first preamble sequence (Preamble Sequence #1).” Additionally, paragraphs 0046-0051 of Jung disclose that the first preamble sequence is divided into subsequences and the generated subsequences are transmitted through the first antenna. Accordingly, Applicant submits that in view of paragraphs 0041 and 0046-0051 of Jung, the “preamble sequence #1” of FIG. 2 of Jung is a consecutive sequence of subsequences of the first preamble sequence. In other words, Jung does not repeat the first preamble sequence in order to create a consecutive sequence, and therefore, the consecutive “preamble sequence #1” illustrated in FIG. 2 of Jung, is patentably distinguishable from the “consecutive sequence” of independent claim 31. Thus, notwithstanding the arguments presented above, Applicant submits that Jung cannot teach or suggest “repeating a specific sequence, having a length (L), N times to generate a consecutive sequence having a length (N*L),” as recited in independent claim 31.

Applicant has demonstrated above that Jung fails to teach or suggest various elements recited in independent claim 31, and therefore, independent claim 31 is allowable over the cited reference. Additionally, independent claim 38 recites elements similar to those recited in independent claim 31 and is allowable for reasons similar to those presented with regard to independent claims 31. Finally, claims 32-37 and 39-44 are allowable at least by virtue of their dependence on an allowable base claim.

Finally, although not formally rejected, newly submitted claims 45 and 46 are allowable at least by virtue of their dependence on an allowable base claim.

CONCLUSION

In light of the above remarks, Applicant submits that the present Amendment places all claims of the present application in condition for allowance. Reconsideration of the application is requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles, California, telephone number (213) 623-2221 to discuss the steps necessary for placing the application in condition for allowance. Please charge any additional fees and credit any overpayment to **Deposit Account No. 502290.**

Respectfully submitted,
Lee, Hong, Degerman, Kang & Waimey

Date: December 16, 2011

By: /Puya Partow-Navid/
Puya Partow-Navid
Registration No. 59,657
Attorney for Applicant(s)

Customer No. 035884

Electronic Acknowledgement Receipt

EFS ID:	11645476
Application Number:	12303947
International Application Number:	
Confirmation Number:	1730
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Customer Number:	35884
Filer:	Puya Partow-Navid/Anna Tounian
Filer Authorized By:	Puya Partow-Navid
Attorney Docket Number:	2101-3596
Receipt Date:	16-DEC-2011
Filing Date:	07-JUL-2010
Time Stamp:	21:12:07
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	2101-3596-Transmittal-ROA.pdf	67361 <small>a432e136d927bfa7fba080b33d204dcc1e700b42</small>	no	1

Warnings:

Information:

2		2101-3596-ROA.pdf	472138	yes	10
			3885157e7a60e672eea6582bce42f585d0a5074f		
Multipart Description/PDF files in .zip description					
		Document Description	Start	End	
		Amendment/Req. Reconsideration-After Non-Final Reject	1	1	
		Specification	2	2	
		Claims	3	5	
		Applicant Arguments/Remarks Made in an Amendment	6	10	

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New Applications Under 35 U.S.C. 111

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AMENDMENT TO THE SPECIFICATION

Please insert the following paragraph on page 1 of the Specification, after the title of the invention and before the section titled TECHNICAL FIELD, with the following heading and paragraph:

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the National Stage filing under 35 U.S.C. § 371 of International Application No. PCT/KR07/02784, filed on January 8, 2007, which claims the benefit and right of priority to Korean Application Nos. 10-2006-0052167, filed on June 9, 2006 and 10-2006-0057488, filed on June 26, 2006.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
 Yeong Hyeon KWON et al.
 Serial No.: 12/303,947
 Filed: July 7, 2010
 For: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

Art Unit: 2478
 Examiner: Khajuria, Shripal K.
 Conf. No. 1730

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

Sir:
 Transmitted herewith is an AMENDMENT in the above-identified application.

- A petition for extension of time for _ month(s) is enclosed.
- No additional fee is required.

The fee has been calculated as shown below:

	(Col. 1) CLAIMS REMAINING AFTER AMENDMENT		(Col. 2) HIGHEST NUMBER PREVIOUSLY PAID FOR		(Col. 3) PRESENT EXTRA*	LG/SM \$ ENTITY FEE		ADD'L FEE DUE
TOTAL CLAIMS FEE	16	-	31	**	0	LG=\$60 SM=\$30	\$60	\$ 0
INDEPENDENT CLAIMS FEE	2	-	7	***	0	LG=\$250 SM=\$125	\$250	\$ 0
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIMS						LARGE ENTITY FEE = \$450 SMALL ENTITY FEE = \$225		\$ 0
TOTAL								\$ 0

* If the entry in Col. 1 is less than the entry in Col. 2, write "0" in Col. 3.
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- The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to **Deposit Account No. 502290**:
 - Excess claim(s) fee in the amount of \$____.
 - RCE fee in the amount of \$____.
 - Extension fees in the amount of \$____.
 - Petition fee in the amount of \$____.
 - Terminal Disclaimer fee in the amount of \$____.
 - Any filing fees under 37 CFR 1.16 for the presentation of extra claims.
 - Any patent application processing fees under 37 CFR 1.17.

Respectfully submitted,
 Lee, Hong, Degerman, Kang & Waimey

Date: December 16, 2011

By: /Puya Partow-Navid/
 Puya Partow-Navid
 Registration No. 59,657
 Attorney for Applicant(s)

Customer No. 035884

Attorney Docket No. 2101-3596

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Yeong Hyeon KWON et al.

Serial No.: 12/303,947

Filed: July 7, 2010

For: METHOD OF TRANSMITTING DATA IN A
MOBILE COMMUNICATION SYSTEM

Art Unit: 2478

Examiner: Khajuria, Shripal K.

Conf. No. 1730

AMENDMENT

Mail Stop Amendment

Commissioner for Patents

P.O. Box 1450

Alexandria, VA 22313-1450

Dear Sir:

In response to the Office Action dated September 16, 2011, for which the Examiner set a three-month period for response, Applicant provides the following.

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/303,947	Filing Date 07/07/2010	<input type="checkbox"/> To be Mailed
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APPLICATION AS FILED – PART I			OTHER THAN SMALL ENTITY			
FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY <input type="checkbox"/>	OR	SMALL ENTITY	
			RATE (\$)		FEE (\$)	
<input type="checkbox"/> BASIC FEE <small>(37 CFR 1.16(a), (b), or (c))</small>	N/A	N/A	N/A			N/A
<input type="checkbox"/> SEARCH FEE <small>(37 CFR 1.16(k), (i), or (m))</small>	N/A	N/A	N/A			N/A
<input type="checkbox"/> EXAMINATION FEE <small>(37 CFR 1.16(o), (p), or (q))</small>	N/A	N/A	N/A			N/A
TOTAL CLAIMS <small>(37 CFR 1.16(j))</small>	14 minus 20 =	* 0	X \$ =	OR	X \$52 =	0
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<input type="checkbox"/> APPLICATION SIZE FEE <small>(37 CFR 1.16(s))</small>	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$250 (\$125 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).					
<input type="checkbox"/> MULTIPLE DEPENDENT CLAIM PRESENT <small>(37 CFR 1.16(j))</small>						
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APPLICATION AS AMENDED – PART II					OTHER THAN SMALL ENTITY				
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AMENDMENT	12/16/2011	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)		ADDITIONAL FEE (\$)		
	Total <small>(37 CFR 1.16(i))</small>	* 16	Minus	** 20	=	0	OR	X \$60=	0
	Independent <small>(37 CFR 1.16(h))</small>	* 2	Minus	***3	=	0	OR	X \$250=	0
	<input type="checkbox"/> Application Size Fee <small>(37 CFR 1.16(s))</small>								
<input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM <small>(37 CFR 1.16(j))</small>									
					TOTAL ADD'L FEE	OR	TOTAL ADD'L FEE	0	

	(Column 1)	(Column 2)	(Column 3)		SMALL ENTITY	OR	SMALL ENTITY		
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)		ADDITIONAL FEE (\$)		
	Total <small>(37 CFR 1.16(i))</small>	*	Minus	**	=	X \$ =	OR	X \$ =	
	Independent <small>(37 CFR 1.16(h))</small>	*	Minus	***	=	X \$ =	OR	X \$ =	
	<input type="checkbox"/> Application Size Fee <small>(37 CFR 1.16(s))</small>								
<input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM <small>(37 CFR 1.16(j))</small>									
					TOTAL ADD'L FEE	OR	TOTAL ADD'L FEE		

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Legal Instrument Examiner:
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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 (Not for submission under 37 CFR 1.99)	Application Number	12303947
	Filing Date	2010-07-07
	First Named Inventor	Yeong Hyeon Kwon
	Art Unit	2478
	Examiner Name	KHAJURIA, SHRIPAL K
	Attorney Docket Number	2101-3596

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STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	KHAJURIA, SHRIPAL K
Attorney Docket Number	2101-3596

1	CHANG ET AL: "Synchronization Method Based on a New Constant Envelop Preamble for OFDM Systems," IEEE TRANSACTIONS ON BROADCASTING, vol. 51, no. 1, March 2005, pp. 139-143, XP-011127926.	<input type="checkbox"/>
2	TEXAS INSTRUMENTS: "On Allocation of Uplink Pilot Sub-Channels in EUTRA SC-FDMA," R1-050822, 3GPP TSG-RAN WG1 Ad Hoc on LTE, August 2005, XP-002448008.	<input type="checkbox"/>

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¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

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(Not for submission under 37 CFR 1.99)

Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	KHAJURIA, SHRIPAL K
Attorney Docket Number	2101-3596

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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- See attached certification statement.
- The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.
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Signature	/David Majdali/	Date (YYYY-MM-DD)	2011-12-20
Name/Print	David Majdali	Registration Number	53,257

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Electronic Acknowledgement Receipt

EFS ID:	11671116
Application Number:	12303947
International Application Number:	
Confirmation Number:	1730
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Customer Number:	35884
Filer:	David Gerard Majdali/Neeti Rajput
Filer Authorized By:	David Gerard Majdali
Attorney Docket Number:	2101-3596
Receipt Date:	20-DEC-2011
Filing Date:	07-JUL-2010
Time Stamp:	21:06:31
Application Type:	U.S. National Stage under 35 USC 371

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	2101-3596_112311_IDSform.pdf	612539 <small>5f56977dbe5f5301337d1e412881fc5e4abd8221</small>	no	4

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2	Non Patent Literature	Chang.pdf	586496	no	6
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Information:

3	Non Patent Literature	Texas_Instruments.pdf	577575	no	8
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National Stage of an International Application under 35 U.S.C. 371

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New International Application Filed with the USPTO as a Receiving Office

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Synchronization Method Based on a New Constant Envelop Preamble for OFDM Systems

Guangliang Ren, Yilin Chang, Hui Zhang, and Huining Zhang

Abstract—The synchronization method using the available constant envelop preamble is analyzed, and a new preamble weighted by pseudo-noise sequence is proposed, with which a novel timing and frequency offset estimation method is presented for orthogonal frequency division multiplexing (OFDM) systems in this paper. By the proposed method, the accuracy of the timing offset estimator is significantly improved, and the estimate range of the frequency offset estimator is greatly enlarged with no loss in accuracy. The performance of the proposed method is demonstrated by simulations.

Index Terms—Constant envelop preamble, OFDM, synchronization.

I. INTRODUCTION

ORTHOGONAL frequency division multiplexing has been widely used in wireless communication systems such as WLANs, DAB, etc. due to its advantages. But it is very sensitive to nonlinear distortion and synchronization errors caused by Doppler shift and/or oscillator instabilities [1]. A number of synchronization methods [2]–[9] have been proposed to estimate the time and frequency offsets either jointly or individually.

In packet oriented application, the preamble based synchronization methods are often employed and most of them use the preamble whose length is more than two OFDM symbols to estimate the timing and frequency offsets [2]–[4]. In order to improve the efficiency of the transmission and the performance of the synchronization method, many algorithms [5]–[8] are investigated to estimate the timing offset and/or the frequency offset wherein the length of the preamble is the same as one OFDM symbol, and the preambles in [5]–[8] can be made by transmitting a pseudo-noise sequence and zeros at the special frequency respectively. However, the peak-to-average power ratio (PAPR) of the preambles is still large due to a large number of sub-carriers in the preamble. So the nonlinear distortion in the transmission degrades the performance of the synchronization method.

In order to achieve robustness to the nonlinear distortion, Andreas Cyzlwink proposed a synchronization method using a constant envelop preamble [9], but the performance of the method is not satisfactory and the ideas in [6]–[8] cannot be applied to the method since the data on the sub-carriers of the constant envelop preamble cannot be selected as those in [6]–[8]. To further improve the performance of the synchronization method

with the constant envelop preamble, we propose a new constant envelop preamble weighted by the pseudo-noise sequence and the corresponding timing and frequency offset estimation method for wireless OFDM systems in this paper.

II. SIGNAL MODEL

The samples of a complex-valued baseband OFDM symbol can be described as

$$x_n = \sum_{k=0}^{N-1} c_k e^{j2\pi kn/N} \quad (1)$$

where c_k is the complex modulated symbol on the k th sub-carrier, N is the size of IFFT and n is the index of samples. The useful part of each OFDM symbol has a duration of T seconds and the intersymbol interference (ISI) can be easily eliminated by inserting a cyclic prefix that is longer than the channel impulse response.

At the receiver, the received waveform $r(t)$ is sampled with period $T_s = T/N$. In the received signal models, the timing offset is often modeled as a delay and the frequency offset is modeled as a phase distortion of the received data in the time domain, so, the u th received sample may be represented as [6]

$$r(n) = y(n - \varepsilon) e^{j(2\pi v n/N)} + w(n) \quad (2)$$

where ε is the integer-valued unknown arrival time of a symbol, v is the frequency offset normalized by the sub-carrier spacing, $w(n)$ is the sample of zero-mean complex Gaussian noise process with variance σ_w^2 , and

$$y(n) = \sum_{m=0}^{L-1} h(m) x_{n-m} \quad (3)$$

where $h(m)$ is the channel impulse response, whose memory is denoted by L .

In OFDM systems, the task of synchronization is to estimate and compensate the timing and frequency offsets.

III. THE AVAILABLE CONSTANT ENVELOP PREAMBLE BASED SYNCHRONIZATION METHOD

The constant envelop preamble generated from DFT of a CAZAC sequence [10], [11] in [9] can be described as

$$X_{\text{preamble}} = [x_0, x_1, \dots, x_{N-1}] \quad (4)$$

where x_i with $i = 0$ to $N - 1$ is the sample of the preamble in time domain. The samples in the preamble satisfy

$$x_i = x_{i+N/2}, \quad i = 0, \dots, \frac{N}{2} - 1 \quad (5)$$

Manuscript received July 1, 2004; revised September 9, 2004. This work was supported in part by the National Natural Science Foundation of China under Grant 60172030.

The authors are with the National Key Laboratory of ISN, Xidian University, Xi'an 710071, China (e-mail: glren@mail.xidian.edu.cn; ylchang@xidian.edu.cn; Huizhang19581@sina.com; sxemitrgl@sina.com).

Digital Object Identifier 10.1109/TBC.2004.842520

and

$$\|x_k\| = C, \quad k = 0, \dots, N-1 \quad (6)$$

where C is a constant number.

The constant envelop preamble contains the two identical halves and has the same structure as that in [4]. In fact, the synchronization algorithms in [4], [9] are essentially based on finding the highest correlation between two repeated sample sequences. Therefore, the metric used to estimate the timing offset in [9] can be defined as

$$M(d) = \frac{|P(d)|^2}{(R(d))^2} \quad (7)$$

where

$$P(d) = \sum_{k=0}^{N/2-1} r^*(d+k)r\left(d+k+\frac{N}{2}\right) \quad (8)$$

$$R(d) = \frac{1}{2} \sum_{k=0}^{N-1} |r(d+k)|^2. \quad (9)$$

The timing offset can be estimated from

$$\hat{\varepsilon} = \arg \max_d (M(d)). \quad (10)$$

Using (10), the correct starting point of OFDM symbol ε_{opt} can be estimated. At the correct starting point, the metric $P(\varepsilon_{\text{opt}})$ is used to estimate the frequency offset, which is given by

$$\hat{\nu} = \frac{1}{\pi} \text{angle}(P(\varepsilon_{\text{opt}})). \quad (11)$$

In the timing offset estimation, it can be seen from (7) that the difference between $M(d)$ and $M(d+1)$ in (7) is too small for they have all the same sum of the product terms

$$r^*(d+1)r\left(d+1+\frac{N}{2}\right) + r^*(d+2)r\left(d+2+\frac{N}{2}\right) \\ + \dots + r^*\left(d+\frac{N}{2}-1\right)r(d+N-1)$$

with the exception of only two product terms $r^*(d)r(d+N/2)$ and $r^*(d+N/2)r(d+N)$, and the timing metric has a plateau due to the cyclic prefix of the preamble, which causes a large variance in the estimation. In the frequency offset estimation, the estimate range defined by (11) is too small, and the large frequency offset deteriorates the performance of the OFDM systems greatly.

In the development of the synchronization methods, based on the method in [4], Minn and Park modified the structure of the preamble by transmitting different data on different sub-carriers to improve the performance of the timing synchronization [5], [6], and Morelli and Song proposed the modified preamble to estimate the frequency offset with a wide estimating range in [7], [8] respectively, but all the ideas in the modified preambles cannot be used to modify the constant envelop preamble since the data of the preamble on the sub-carriers cannot be selected as those for modified preambles. It is also noted that the constant envelop property of the preamble is not utilized in synchronization.

To make full use of the advantages of the constant envelop preamble in the transmission, we introduce a PN sequence weighted factor into the preamble to improve the performance of the synchronization method.

IV. PROPOSED SYNCHRONIZATION METHOD

A. New Preamble

To enlarge the difference between $M(d)$ and $M(d+1)$ of the preamble given by (7), the pseudo-noise (PN) sequence weighted factors are introduced, and the new preamble can be defined as

$$x'_k = s_k x_k, \quad k = 0, 1, \dots, N-1 \quad (12)$$

where s_k is the PN sequence weighted factor of the k th sample of the original preamble. The value of the PN sequence is $+1$ or -1 .

B. Timing Offset Estimation

At the correct starting point of the proposed preamble, the weighted factors can be removed by multiplying the preamble by the corresponding PN sequence. The two identical parts in the processed preamble are fully correlated. So, the new timing metric can be defined as

$$M(d) = \frac{|P(d)|^2}{(R(d))^2} \quad (13)$$

where

$$P(d) = \sum_{k=0}^{N/2-1} s_k s_{k+N/2} r^*(d+k)r\left(d+k+\frac{N}{2}\right) \quad (14)$$

$$R(d) = \frac{1}{2} \sum_{k=0}^{N-1} |r(d+k)|^2. \quad (15)$$

It is obvious from (14) that the correlation property of the PN sequence weighted factors ensures that the proposed timing metric $M(d)$ has its peak value at the correct symbol starting point, while the values at all other points are comparatively smaller, which leads to a much smaller error of timing offset estimation. The new timing metric like that in [4]–[6] is robust to the frequency offset.

C. Frequency Offset Estimation

After the timing synchronization, the starting point of the received preamble can be determined. Similar to frequency offset estimation in [4], [9], the metric $P(d)$ at the correct starting point ε_{opt} can also be used to estimate the frequency offset

$$\hat{\nu}_1 = \frac{1}{\pi} \text{angle}(P(\varepsilon_{\text{opt}})). \quad (16)$$

The range of the frequency estimate given by (16) is ± 1 due to the period of phase function $\text{angle}(\cdot)$. When the absolute frequency offset ν is greater than 1, the relation between ν and $\hat{\nu}_1$ can be represented as

$$\nu \approx 2q + \hat{\nu}_1 \quad (17)$$

where q is the number of the ambiguity period. In the frequency synchronization, it is necessary to estimate q when the absolute frequency offset is greater than one.

In order to estimate q in a simple way, the received preamble is first compensated by \hat{v}_1 , which can be represented as

$$\begin{aligned} r_1(k) &= r(k)e^{-j(2\pi\hat{v}_1 k/N)} \\ &= y_k e^{j(2\pi(v-\hat{v}_1)k/N)} + w(k)e^{-j(2\pi\hat{v}_1 k/N)} \\ &= y_k e^{j(2\pi q k/N)} + w_1(k) \\ &= h_0 s_k x_k e^{j(4\pi q k/N)} \\ &\quad + \sum_{m=1}^{L-1} h_m s_k x_{k-m} e^{j(4\pi q k/N)} + w_1(k) \end{aligned} \quad (18)$$

where $w_1(k) = w(k)e^{-j(2\pi\hat{v}_1 k/N)}$. Then, multiply the samples of the compensated received preamble in (18) with the samples of the transmitted constant envelop preamble given by (12), which can be described as

$$\begin{aligned} r_2(k) &= r_1(k) \cdot c_k^{*k} \\ &= h_0 |x_k|^2 e^{j(4\pi q k/N)} \\ &\quad + \sum_{m=1}^{L-1} h_m s_k s_{k-m} x_{k-m} x_k^* e^{j(4\pi q k/N)} + s_k x_k^* w_1(k) \\ &= h_0 C e^{j(4\pi q k/N)} + w_2(k) \end{aligned} \quad (19)$$

where

$$w_2(k) = \sum_{m=1}^{L-1} h_m s_k s_{k-m} x_{k-m} x_k^* e^{j(4\pi q k/N)} + s_k x_k^* w_1(k). \quad (20)$$

It is easy to find from (19) that the frequency offset estimation turns to be the frequency estimation of a complex tone. There are many algorithms [12] for the frequency estimation, and most of them are based on the periodogram. So, the simple standard periodogram algorithm with high performance in [12] is applied. Therefore, the estimate of q can be defined as

$$\hat{q} = \arg \max_q (I(q)) \quad (21)$$

where

$$I(q) = \left| \sum_{i=0}^{N-1} r_2(k) e^{-j4\pi q k/N} \right|^2, \quad q = -\frac{N}{4}, \dots, 0, 1, \dots, \frac{N}{4}. \quad (22)$$

Therefore, the total frequency offset can be represented as

$$\hat{v} = 2\hat{q} + \hat{v}_1. \quad (23)$$

From (23), it can be found that the range of the new frequency offset method is $\pm N/2$.

In the AWGN channel, the Cramer-Rao lower bound (CRLB) for \hat{v}_1 [4] is

$$\text{var}(\hat{v}_1) \geq \frac{2}{\pi^2 N \cdot \text{SNR}} \quad (24)$$

where the SNR is the ratio of the signal to noise power, and the Cramer-Rao lower bound (CRLB) for \hat{q} [12] is

$$\text{var}(\hat{q}) \geq \frac{3}{4\pi^2 N(N^2 - 1) \cdot \text{SNR}}. \quad (25)$$

Since the error generated by \hat{v}_1 and the error by \hat{q} are independent, the errors in two estimators may be assumed to be inde-

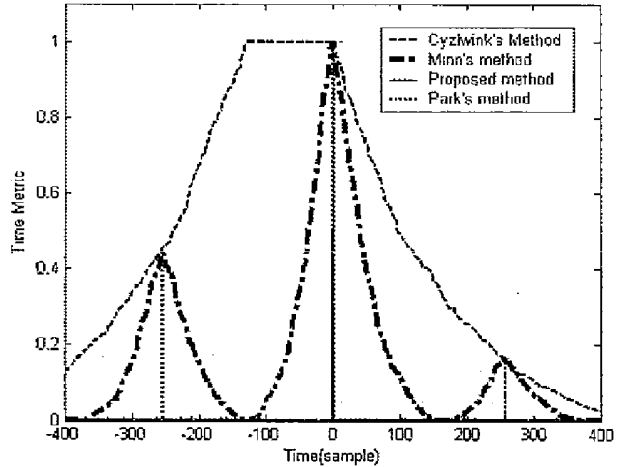


Fig. 1. The timing metric of estimators.

pendent, and the Cramer-Rao lower bound (CRLB) for \hat{v} can be represented as

$$\text{var}(\hat{v}) \geq \frac{12}{4\pi^2 N(N^2 - 1) \cdot \text{SNR}} + \frac{2}{\pi^2 N \cdot \text{SNR}}. \quad (26)$$

V. PERFORMANCE EVALUATION, SIMULATION RESULTS, AND DISCUSSION

A. Simulation Parameters

The performance of the proposed synchronization method is investigated by computer simulation. The OFDM system parameters used are 1024 subcarriers, 1024 point IFFT/FFT, and 12.5% guard interval (128 samples). Unless stated otherwise, 10 000 simulation runs will be applied.

The channels considered are described in the following. All channels have 16 taps with an equal tap spacing of 8 samples. The Rayleigh fading channel has an exponential power delay profile and the ratio of the first fading tap to the last fading tap is set to be 24 dB. The channel coefficient is time-invariant since the coherence time is much longer than the burst duration.

B. Timing Synchronization Performance

In order to make a convenient comparison with the proposed method, the timing synchronization methods with constant envelop and nonconstant envelop preambles in [5], [6] are also simulated. Fig. 1 shows the timing metrics of Cyzlwin's method [9], Minn's method [5], Park's method [6] and the proposed method under the circumstances of no noise and no channel distortion. The correct timing point is indexed as 0 in the Fig. 1 and taken as the starting position of the useful part of the OFDM symbol.

As seen in Fig. 1, the timing metric of the proposed method and that of Park's method have an impulse-like shape, and the impulses of the two methods overlap at the correct timing point. Compared with the values of the timing metric of Park's

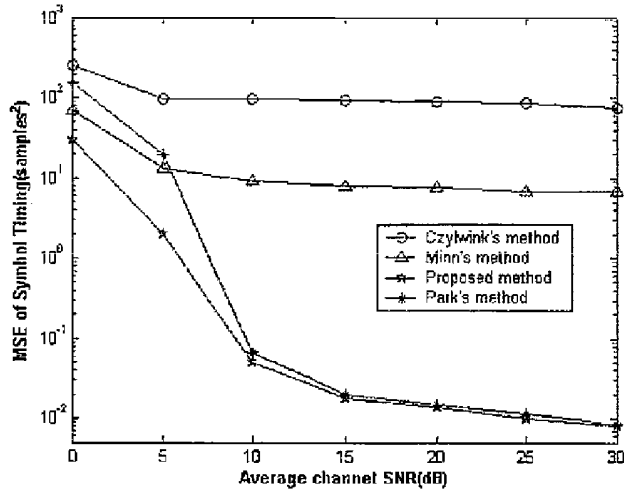


Fig. 2. MSE of timing offset versus SNR for four methods.

method, those of the proposed method at the other positions are much smaller, which makes the proposed method offer a more accurate timing offset estimation.

The mean square error (MSE) reflects both the bias and the variance of the estimation. Therefore, the performance of the proposed estimator is evaluated by the mean square error (MSE), and compared with Minn's method, Park's method and Czulwink's method. Fig. 2 shows the MSEs of the four methods in the Rayleigh channel. We can see that the proposed method has a much smaller MSE than Minn's method and Czulwink's method. Compared with Park's method, when the SNR is less than 15 dB, it can be seen that the MSE of the proposed method is smaller than that of Park's method, but that they are almost the same when the SNR is greater than 15 dB.

C. Frequency Synchronization Performance

Based on the timing synchronization, the starting point of the preamble can be determined. The performance of the frequency offset estimation in Czulwink's method is the same as that in Minn's method and Park's method, and therefore, in simulation, only the frequency synchronization method in Czulwink's method is simulated. In order to make a convenient comparison with the proposed method, the multistage method in [8] and Morelli's method in [7] are also simulated.

In the multistage method and Morelli's method, the number of the identical parts in the preambles is limited due to the average operations. In order to enlarge the estimation range of the multistage method and Morelli's method further, the preambles consisting of 32 identical parts are considered. Fig. 3 illustrates the average estimate as a function of the real normalized offset for the SNR = 20 dB. The ideal curve is also shown for comparison. We can see from the curves in Fig. 3 that the available normalized frequency offset estimation range of the multistage method and Morelli's method is ± 16 , and that of Czulwink's method in [9] is only ± 1 . The average estimate of the proposed method is almost the same as that for the ideal case, and the tested estimation range of the proposed method in the simulation is ± 512 , which is consistent with (15). Therefore, the esti-

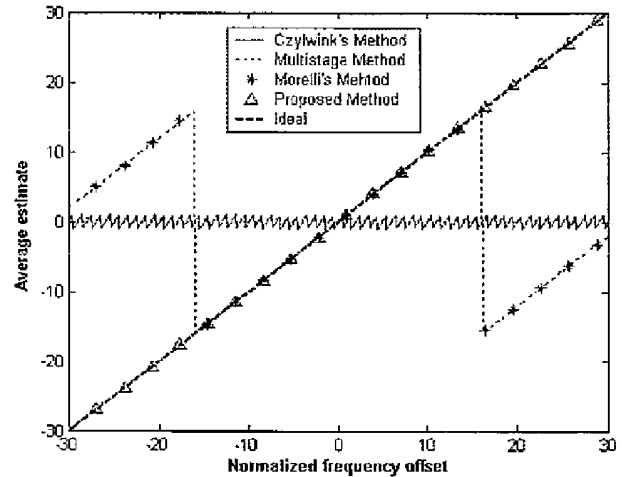


Fig. 3. Average frequency estimate versus normalized frequency offset.

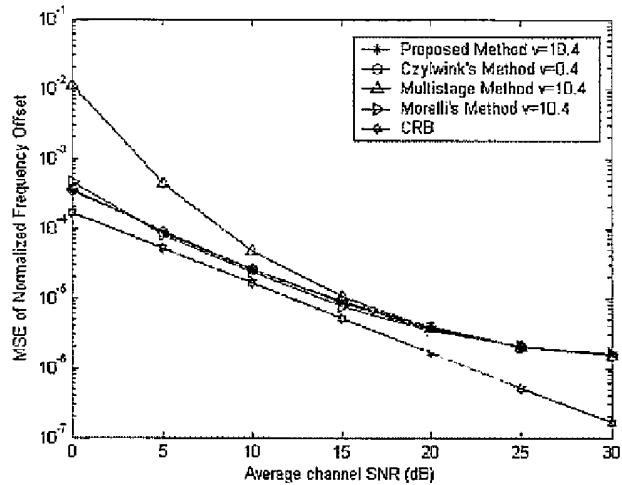


Fig. 4. MSE of frequency offset estimation versus SNR.

mation range of the proposed method is wider than those of the methods in [7], [8] since the number of the identical parts in the preamble is much less than 1024.

The mean square errors (MSEs) of the four methods versus SNR and the Cramer-Rao lower bound (CRLB) of the proposed method are shown in Fig. 4. The normalized frequency offset is set to be $v = 0.4$ and 10.4. It is obvious that the MSE of the proposed method is almost the same as those of Czulwink's method with $v = 0.4$ and Morelli's method, but less than that of the multistage method at a low SNR. Therefore, the proposed method has a wider estimation range with no loss in accuracy. For the same estimate range, the computational complexity of the proposed method is about the same order as that of Morelli's method.

VI. CONCLUSIONS

In order to improve the synchronization performance of wireless OFDM systems with the constant envelop preamble, we suggested a new constant envelop preamble weighted by

the pseudo-noise sequence and the corresponding timing and frequency offset estimation method. The new synchronization algorithm exploits the correlation property of the PN sequence and the two identical parts in the preamble to estimate the timing offset, and the constant envelop property of the preamble is used to estimate the frequency offset with a wide estimate range. Simulations show that the timing accuracy and the estimate range of the frequency offset in the proposed synchronization are significantly improved. Therefore, the proposed method is suitable for improving the performance of the synchronization for the OFDM system in wireless channels with a large frequency offset.

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Source: Texas Instruments
Title: On Allocation of Uplink Pilot Sub-Channels in EUTRA SC-FDMA
Agenda Item: 10.3
Document for: Discussion

1. Introduction

1.1 Problem Formulation

One of the two possible TTI structures for uplink Single Carrier FDMA (SC-FDMA) as proposed by Drafting group 1 is given in Figure 1 below.



Figure 1: Uplink TTI structure for SC-FDMA.

In Figure 1, LB represents a “Long Block,” which can contain only data symbols, and SB represents a “Short Block,” which can contain either pilot or data symbols. Therefore, the uplink pilot is always confined inside the SB field. The time duration of the SB field is half of the time duration of the LB field. The rest of the numerology for the uplink frame structure is given in [1].

The proposed uplink TTI structure results in the frequency set where the width of pilot subcarriers is twice the width of data subcarriers. For example, in the baseline case of 5MHz bandwidth, pilot and data subcarriers are as given in Figure 2 below.

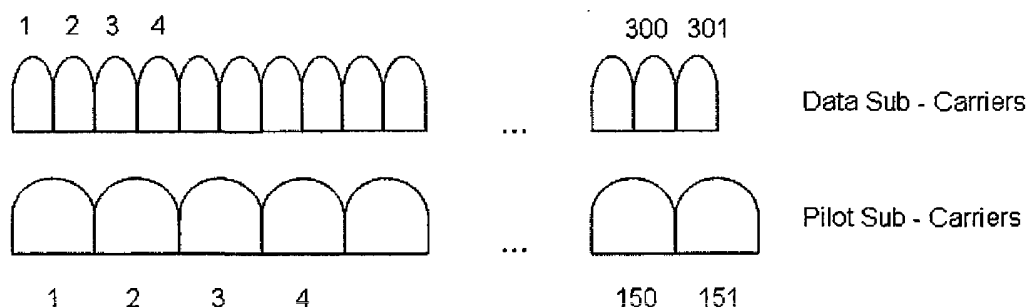


Figure 2: Frequency Set for SC-OFDM.

In the case of distributed (IFDMA) uplink transmission, each mobile is allocated a set of non-contiguous tones for data subcarriers. In this case, it is unclear as to which is the most appropriate allocation of uplink pilot resources. The following options should be considered.

1.2 Possible Allocations for Orthogonal Uplink Pilot

a) Time Domain Orthogonality

Time domain orthogonality is the most obvious alternative for usage of the SB field for pilot transmission. However, such a solution may result in a high peak to average ratio (PAR) for uplink transmission, which would decrease coverage due to the amplifier back-off.

b) Frequency Domain Orthogonality

Frequency domain orthogonality is another proposed solution for the uplink orthogonal pilot, which is a topic of current studies. The main difficulty faced by a frequency domain orthogonal pilot is for UE's near the cell border when the neighboring cell utilizes the same uplink pilot channel. For this reason, frequency domain orthogonality of the uplink pilot requires careful frequency planning and reuse patterns.

c) Code Domain Orthogonality

Code domain orthogonality can be achieved with a use of Constant Amplitude Zero Autocorrelation (CAZAC) sequences, as we demonstrate in the remainder of this document. Furthermore, CAZAC sequences have a flat frequency domain response, which makes them attractive for SC – OFDMA systems.

d) Code-Frequency Domain Orthogonality

Code-Frequency domain orthogonality is a hybrid alternative between b) and c), which uses a combination of CAZAC sequences and distributed FDMA transmission to achieve an uplink orthogonal pilot.

In this contribution, we focus on the Code Domain Orthogonality.

1.3 Background on CAZAC Sequences

An example of CAZAC sequences is given as follows. Let L be any positive integer, and let k be any number which is relatively prime with L . Then the n -th entry of the k -th Zadoff-Chu CAZAC sequence [2] is given as follows:

$$c_k(n) = \exp\left[\frac{j2\pi k}{L}\left(n + n\frac{n+1}{2}\right)\right] \quad \text{if } L \text{ is odd}$$
$$c_k(n) = \exp\left[\frac{j2\pi k}{L}\left(n + \frac{n^2}{2}\right)\right] \quad \text{if } L \text{ is even}$$

The set of Zadoff-Chu CAZAC sequences has the following properties:

- Constant magnitude
- Zero circular autocorrelation
- Flat frequency domain response
- Low, constant magnitude, cross-correlation, provided that L is a prime number.

2. Proposal: Allocation of Uplink Pilot Sub-Channels

In this section we demonstrate how to achieve the uplink orthogonal pilot in the code domain with the use of CAZAC sequences. The main idea is to use a single CAZAC sequence per sector and exploit the property of zero circular autocorrelation along with the cyclic prefix transmission.

2.1 Allocation of Pilot Sub-Channels for a Single Sector

2.1.1 Option 1: Orthogonality in the Code Domain

In order to illustrate how to achieve orthogonality in the code domain, we let the CAZAC sequence be “ c ,” and let its right cyclic shift by Q be specified as $S_Q(c)$. Since the sequence has zero cyclic autocorrelation, then $S_0(c)$, $S_Q(c)$, $S_{2Q}(c)$... $S_{MQ}(c)$ are all orthogonal provided that MQ does not exceed the length of the sequence. Furthermore, even when $S_0(c)$ is cyclically right-shifted by less than Q samples, it remains orthogonal to the rest of $S_Q(c)$, $S_{2Q}(c)$... $S_{MQ}(c)$. Next, we simply allocate $S_0(c)$ to be

the pilot sequence for UE#0, $S_Q(c)$ to be the pilot sequence for UE#1, and proceed accordingly until we allocate $S_{MQ}(c)$ to be the pilot sequence for UE#M. Such an allocation is illustrated in the following figure.

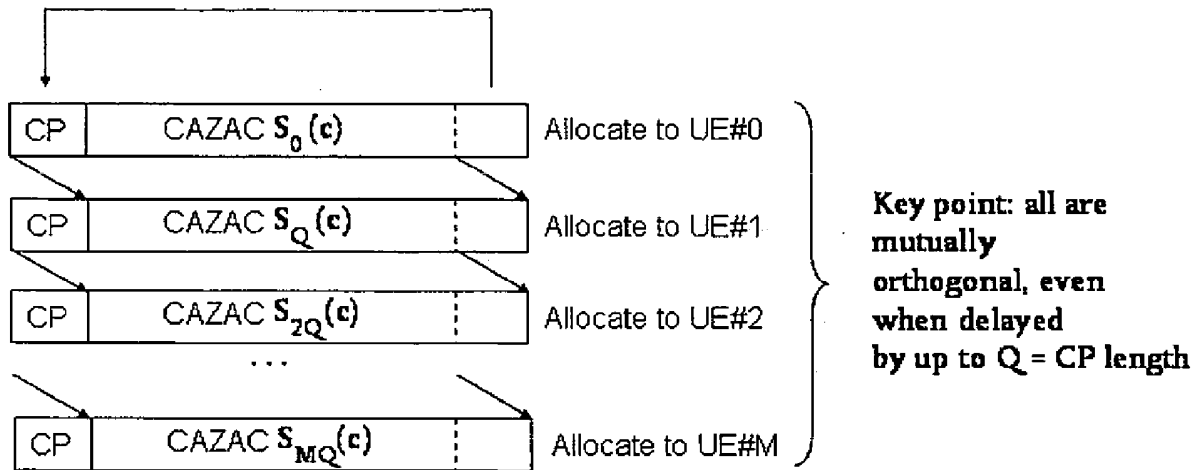


Figure 3: Proposed Allocation of Uplink Pilot Sequences.

With such an allocation, the arriving multipath signal from each UE will be orthogonal, under the assumption that Q is longer than each delay profile. For this reason an appropriate choice for Q is the prefix length of the transmission. Alternatively, a more conservative allocation would accommodate scenarios where the delay profile is longer than the prefix length. In such cases, Q should be longer than the transmission prefix.

2.1.2 Option 2: Orthogonality in the Code-Frequency Domain

Since distributed (IFDMA) transmission can be simply achieved by block repetition in the time domain, the extension of section 2.1.1 to orthogonality in the Code-Frequency domain is straightforward. Namely, upon the above described uplink pilot sequence allocation, one can perform block repetition to achieve distributed FDMA transmission. In this manner, multiple UE's utilize the same IFDMA uplink pilot channel through the use of cyclically shifted CAZAC sequences.

2.2 Allocation of Pilot Sub-Channels in Softer Handover

For UE's which are in the Softer Handover, the transmitted signal is received with significant power level in two sectors of the Node B. In order to avoid UE self-interference, we propose that both serving sectors allocate the same CAZAC sequence, with the exact same shift, to UE's which are shared in the Softer Handover. Hence, each sector of a single Node B will utilize the same CAZAC sequence.

2.3 Allocation of Pilot Sub-Channels between different Node B's

Neighboring Node B's should utilize different CAZAC sequences for the uplink pilot channel in order to achieve interference averaging. For this reason, the most appropriate choice for CAZAC sequences are Zadoff-Chu sequences of prime length (see Background section above), which have low constant magnitude cyclic cross-correlation. Since the number of different Zadoff-Chu sequences is close to the length of the sequence itself (hence large), there are no difficulties in constructing the reuse pattern for distant Node B's.

2.4 Number of CAZAC sequences

As stated earlier in the background section, Zadoff – Chu sequences have low constant magnitude cross – correlation; provided that their length is a prime number. In this section, we present the number of possible sequences, assuming the exact uplink numerology from [1], Option2.

Table 1: Number of CAZAC Sequences

	1.25MHz	2.5MHz	5MHz	10MHz	15MHz	20MHz
LB Samples	128	256	512	1024	1536	2048
Used Subcarriers in LB	76	151	301	601	901	1201
SB Samples	64	128	256	512	768	1024
Used Subcarriers in SB	37	73	151	293	449	601
CP Samples	7	15	31	63	95	127
# of distinct CAZACs not including shifts	36	72	150	292	448	600
# of distinct CAZACs including 8 shifts	288	576	1200	2336	3584	4800

Table 1 is derived as follows. Rows 2 and 4 are from the uplink proposal in [1], Option2. Row 3 hasn't been agreed upon yet (for the uplink), which is why we assumed the downlink numerology from [1]. Row 5 is proposed to be the prime number which is closest to half of the Row 3. Row 6 is directly from [1]. Row 7 is derived based of properties (see background section) of Zadoff – Chu sequences. Finally, Row 8 is $8 * \text{Row 7}$, since the SB (Row 4) accepts 8 distinct circular shifts by the cyclic prefix (Row 6).

2.5 Simulation Results

Table 2: Simulation Assumptions

Parameter		Assumption
Bandwidth		5 MHz (2.6 GHz)
Channel Model		TU
Data Channel Turbo Coding		Rate 1/2
Data Modulation		16QAM
Uplink Numerology		Option 2 in [1] (Table 9.1.1.2)
Pilot Sequence/Modulation		QPSK Random Sequence vs. Constant Amplitude Zero Autocorrelation (CAZAC)
Pilot Average Power Boost		2.5 dB (Peak Pilot Power = Peak Data Power)
Data Channel		FDMA which occupies each 4 th tone. Number of Subcarriers = 64
Pilot Channel		Occupies the entire transmission band with 2 short blocks per TTI
Antenna Configuration		1 at Transmitter, 2 at Receiver
Channel Estimation	Time Interpolation	Doppler dependent filter coefficients MF – Wiener Matched Filter ZF – Wiener Zero Forcing Filter
	Frequency Interpolation	Least Squares
	Interpolation Method	Past, Current and Future TTI

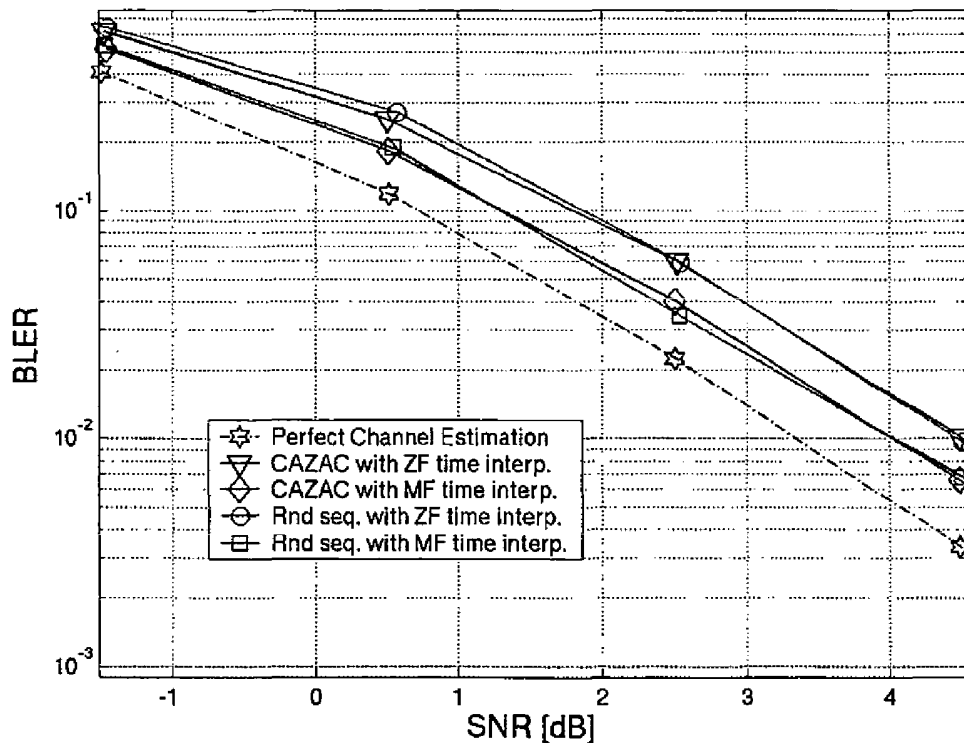


Figure 4: Block Error Rates (BLER) for Random QPSK Pilot, and CAZAC Pilot, at UE Speed = 3kmph.

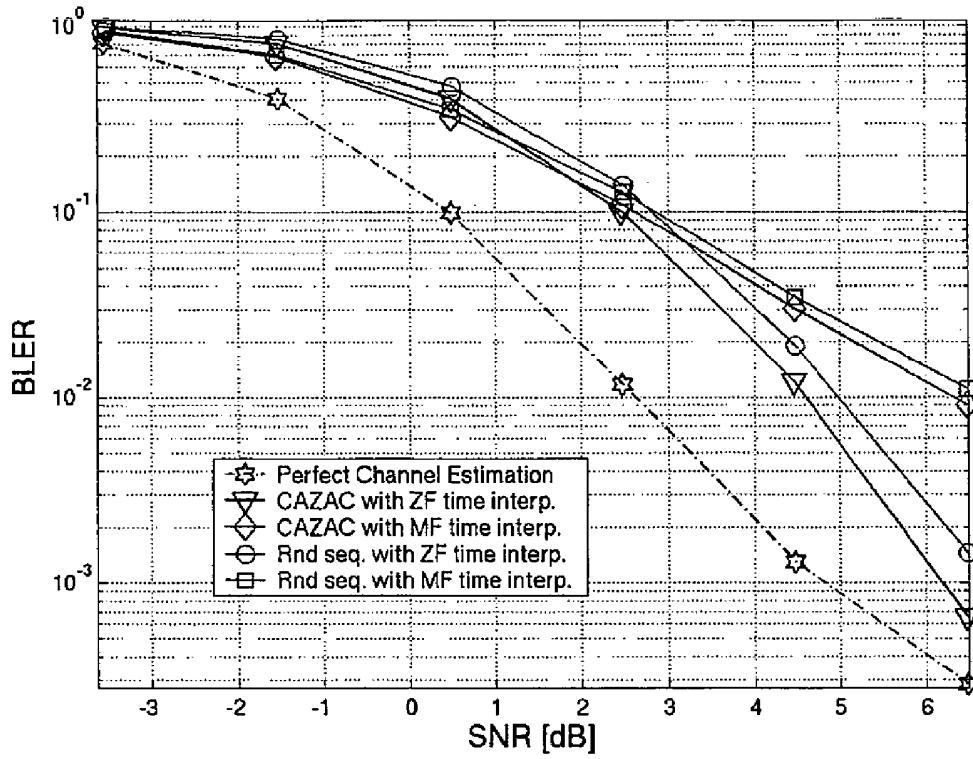


Figure 5: Block Error Rates for Random QPSK Pilot, and CAZAC Pilot, at UE Velocity = 150kmph

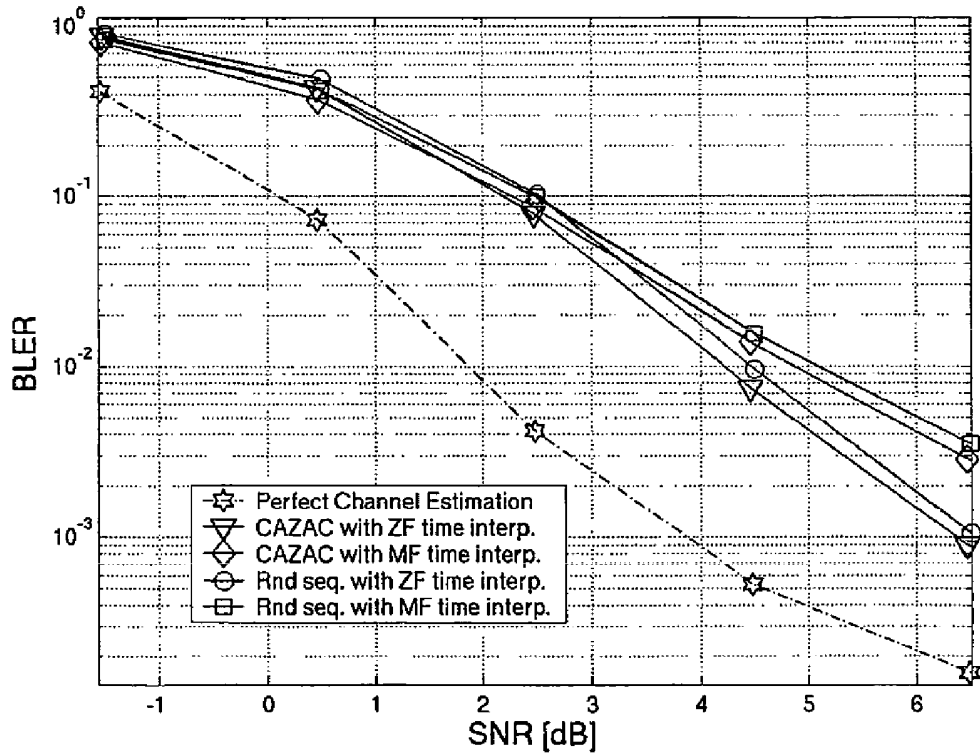


Figure 6: Block Error Rates for Random QPSK Pilot, and CAZAC Pilot, at UE Velocity = 360kmph.

As we see from the above simulation results (for single UE), the choice of a CAZAC sequence offers superior channel estimation results at higher UE velocities. Specifically, the CAZAC pilot sequence offers up to 0.4dB gain when compared to the Random pilot sequence at 150kmph and 0.3dB at 360kmph. At 3kmph, the performance of CAZAC and Random pilot sequences are close. Furthermore, multiple UEs which utilize cyclic shifts of a single CAZAC sequence do not mutually interfere, which is not the case with Random sequences. Further simulations will be provided in future meetings.

3. Conclusion

The set of Zadoff-Chu CAZAC uplink pilot sequences presents an attractive solution for the uplink pilot design in LTE. In this document we presented a method for reuse of a single CAZAC sequence with cyclic shifts in order to achieve orthogonality in the uplink pilot channel. Furthermore, interference management between different cells is fairly simple because it reduces to assigning different CAZAC sequences to neighboring cells.

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APPARATUS AND METHOD FOR TRANSMITTING A BURST PILOT CHANNEL IN A MOBILE COMMUNICATION SYSTEM

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Disclosed are a method and apparatus for transmitting a time-discontinuous burst pilot channel being dependent on transmission data in a mobile communication system. In the apparatus, a modulator generates a modulated pilot symbol by outputting an input pilot symbol at a designated at least one of phase and on a designated complex channel according to an information bit for determining at least one of the phase and/or the complex channel, and a spreader spreads the modulated pilot symbol from the modulator with an orthogonal code selected among a plurality of orthogonal codes. The burst pilot channel transmits side information being dependent on the transmission data according to the phase, and/or the complex channel and the orthogonal code.

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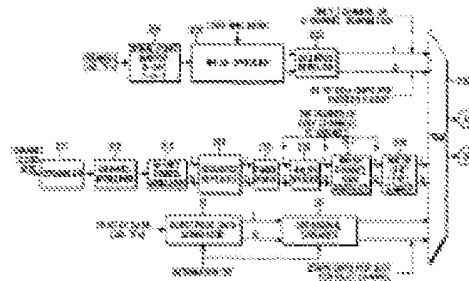
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要約書に続く

(54) 【発明の名称】 移動通信システムでのバーストパイロットチャネル送信装置及び方法

(57) 【要約】

本発明は、移動通信システムで伝送されるデータに依存する時間的に不連続的なバーストパイロットチャネルを送信するための装置であって、少なくとも一つの位相及び複素チャネルを決定する情報ビットにตอบสนองして入力パイロットチャネルデータを少なくとも一つの決定された位相及び複素チャネル上に出力することによりパイロット変調シンボルを発生する変調器10と、前記変調器から前記パイロット変調シンボルを入力し、複数の直交符号中、選択された直交符号に前記パイロット変調シンボルを拡散する拡散器20とを備えて、前記バーストパイロットチャネルは前記少なくとも一つの位相、複素チャネル及び直交符号によって前記伝送されるデータに依存する付加情報を伝送することを特徴とする。



【特許請求の範囲】

【請求項1】

移動通信システムで伝送されるデータに依存する時間的に不連続的なバーストパイロットチャンネルを送信するための装置において、
 少なくとも一つの位相及び複素チャンネルを決定する情報ビットに依存して入力パイロットチャンネルデータを少なくとも一つの決定された位相及び複素チャンネル上に出力することによりパイロット変調シンボルを発生する変調器と、
 前記変調器から前記パイロット変調シンボルを入力し、複数の直交符号中、選択された直交符号に前記パイロット変調シンボルを載せる載搬器と
 を備えて、

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前記バーストパイロットチャンネルは前記少なくとも一つの位相、複素チャンネル及び直交符号によって前記伝送されるデータに依存する付加情報を伝送することを特徴とする装置、

【請求項2】

前記パイロット変調シンボルは、128チップの長さを有することを特徴とする請求項1に記載の装置、

【請求項3】

前記パイロット変調シンボルは、64チップの長さを有することを特徴とする請求項1に記載の装置、

【請求項4】

前記複素チャンネルは、Iチャンネル及びQチャンネルの構成されることを特徴とする請求項1に記載の装置、

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【請求項5】

移動通信システムでバーストパイロットチャンネルを通じて付加情報を伝送するための装置において、

位相を決定する情報ビットに依存して入力パイロットチャンネルデータを決定された位相で出力することによりパイロット変調シンボルを発生する変調器と、
 前記変調器からのパイロット変調シンボルを予め設定された直交符号に載せる載搬器とを備えることを特徴とする装置、

【請求項6】

移動通信システムでバーストパイロットチャンネルを通じて付加情報を伝送するための装置において、

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複素チャンネルを決定する情報ビットに依存して入力パイロットチャンネルデータを決定された複素チャンネル上に出力することによりパイロット変調シンボルを発生する変調器と、
 前記変調器からのパイロット変調シンボルを予め設定された直交符号に載せる載搬器とを備えることを特徴とする装置、

【請求項7】

移動通信システムでバーストパイロットチャンネルを通じて付加情報を伝送するための装置において、

バーストパイロットシンボルを発生する変調器と、
 前記バーストパイロットシンボルを複数の直交符号中、情報ビットにより選択された直交符号に載せる載搬器と
 がいなることを特徴とする装置、

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【請求項8】

移動通信システムでバーストパイロットチャンネルを通じて付加情報を伝送するための装置において、

位相を決定する情報ビットに依存して入力パイロットチャンネルデータを決定された位相で出力することによりパイロット変調シンボルを発生する変調器と、
 前記パイロット変調シンボルを複数の直交符号中、情報ビットにより選択された直交符号に載せる載搬器と
 がいなることを特徴とする装置、

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【請求項 9】

移動通信システムをバーストパイロットチャネルを通じて付加情報を伝送するための装置において、
 複素チャネルを決定する情報ビットに responding して入力パイロットチャネルデータを決定された複素チャネル上に出力することによりパイロット変調シンボルを発生する変調器と、
 前記パイロット変調シンボルを複数の直交符号中、情報ビットにより選択された直交符号に載搬する載搬器と
 がらなることを特徴とする装置。

【請求項 10】

移動通信システムで伝送されるデータに依存する時間的に不連続的なバーストパイロットチャネルを送信するための方法において、
 少なくとも一つの位相及び複素チャネルを決定する情報ビットに responding して入力パイロットシンボルを少なくとも一つの決定された位相及び複素チャネル上に出力することによりパイロット変調シンボルを発生する過程と、
 前記パイロット変調シンボルを複数の直交符号中、選択された直交符号に載搬する過程とを備えて、
 前記バーストパイロットチャネルは前記位相及び/または複素チャネル及び直交符号によって前記伝送されるデータに依存する付加情報を伝送することを特徴とする方法。

【請求項 11】

前記パイロット変調シンボルは、128チップの量を有することを特徴とする請求項10に記載の方法。

【請求項 12】

前記パイロット変調シンボルは、64チップの量を有することを特徴とする請求項10に記載の方法。

【請求項 13】

前記複素チャネルは、Iチャネル及びQチャネルに構成されることを特徴とする請求項10に記載の前記方法。

【請求項 14】

移動通信システムをバーストパイロットチャネルを通じて付加情報を伝送するための方法において、
 位相を決定する情報ビットに responding して入力パイロットシンボルを決定された位相に出力することによりパイロット変調シンボルを発生する過程と、
 前記発生されたパイロット変調シンボルを予め設定された直交符号に載搬する過程とを包むことを特徴とする方法。

【請求項 15】

移動通信システムをバーストパイロットチャネルを通じて付加情報を伝送するための方法において、
 複素チャネルを決定する情報ビットに responding して入力パイロットシンボルを決定された複素チャネル上に出力することによりパイロット変調シンボルを発生する過程と、
 前記発生されたパイロット変調シンボルを予め設定された直交符号に載搬する過程とを包むことを特徴とする方法。

【請求項 16】

移動通信システムをバーストパイロットチャネルを通じて付加情報を伝送するための方法において、
 パイロットシンボルを発生する過程と、
 前記発生されたパイロットシンボルを複数の直交符号中、情報ビットにより選択された直交符号に載搬する過程と
 がらなることを特徴とする方法。

【請求項 17】

移動通信システムをバーストパイロットチャネルを通じて付加情報を伝送するための方法

に於いて、
 送信を決定する複数のビットに responding して入力パイロットシンボルを決定された位相を出力する
 ことによりパイロット変調シンボルを発生する過程と、
 前記発生されたパイロット変調シンボルを複数の直交符号中、複数のビット入力符号により
 編入された直交符号に復調する過程と
 ならぬことを特徴とする方法。

【実施例 1 の】

移動通信システムがバーストパイロットチャネルを通じては加雑音を低減するための方法
 に於いて、

送信チャネルを決定する複数のビットに responding して入力パイロットシンボルを決定された変調
 チャネル上に出力することによりパイロット変調シンボルを発生する過程と、
 前記発生されたパイロット変調シンボルを複数の直交符号中、複数のビットにより編入され
 た直交符号に復調する過程と
 ならぬことを特徴とする方法。

【発明の利便性説明】

【0001】

【発明の属する技術分野】

本発明は移動通信システムに関するもの、特にパイロットチャネル (Pilot Channel) を通じて雑音を低減するための装置及び方法に関する。

【0002】

【従来の技術】

最近、高速データ伝送が要求されつつ、音声サービスだけでなく、高速パケットデータ
 サービスを支援するための移動通信システムが提案されている。前記高速パケットデータ
 伝送を支援する移動通信システムは、送信端でパケットデータを QAM (Quadrature
 Amplitude Modulation) を用いて送信し、受信端で連続的な
 共通パイロット (Common Pilot) チャネルと時間的に不連続的なバースト
 パイロット (Burst Pilot) チャネルなどを送信する。

【0003】

一般的に、QPSK (Quadrature Phase Shift Keying) の
 ような位相変調方式は、変調シンボルの位相成分の情報が含まれている。従って、受信側
 では共通パイロットチャネルを位相基準信号に利用して変調シンボルを復調している。し
 かし、QAM 変調方式は変調シンボルの振幅及び位相成分の情報が含まれている。例えば
 、前記高速データ伝送を支援するシステムでパケットデータ伝送のために、16-QAM、
 または 64-QAM などの変調方式を使用する場合、受信端で変調シンボルに含まれてい
 る情報を正確に復調するためには、変調シンボルの振幅基準 (Amplitude Reference)
 が必要である。そのため、変調シンボルの位相基準及び振幅基準に
 なる信号をすべて伝送すべきである。即ち、送信端で一定の電力帯にデータを伝送する QAM
 変調方式を使用する場合、共通パイロットチャネルを位相及び振幅基準に共に使用する
 こととするか、伝送される電力帯が特定帯域にのみ変化する場合、伝送 QAM 変調シン
 ボルの振幅基準を提供する基準信号が必要である。前記 QAM 変調シンボルの振幅基準を
 提供するために、前記バーストパイロットチャネルを使用する。即ち、前記バーストパイ
 ロットチャネルは QAM 変調シンボルの振幅のみを提供するために使用される。一般的に
 、移動通信システムは制限された無線資源を効果的に使用するのが第一要務である。従っ
 て、複合的な機能を遂行する多くのチャネルが提案されている。前記バーストパイロット
 チャネルは変調シンボルの振幅基準を提供するために使用されているが、付加的に他の情
 報を提供することとする。すなわち割り当てられているチャネルを使用するとの余り制
 限された資源を効果的に使用することとする方法になるだろう。

【0004】

【発明が解決しようとする課題】

従って、本発明の目的は、変調シンボルの振幅基準を提供するバーストパイロットチャネ

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ルを利用して付加情報を伝送するための装置及び方法を提供することにある。

【0005】

本発明の他の目的は、変調シンボルの振幅基準を提供するバーストパイロット変調シンボルの位相成分を利用して付加情報を伝送するための装置及び方法を提供することにある。

【0006】

本発明のさらに他の目的は、変調シンボルの振幅基準を提供するバーストパイロット変調シンボルの電力復素チャネルを利用して付加情報を伝送するための装置及び方法を提供することにある。

【0007】

本発明のさらに他の目的は、変調シンボルの振幅基準を提供するバーストパイロット変調シンボルの振幅符号を利用して付加情報を伝送するための装置及び方法を提供することにある。

【0008】

【課題を解決するための手段】

前記目的を達成するための本発明は、移動通信システムで伝送されるデータに依存する時間の不連続的なバーストパイロットチャネルを送信するための装置を提供する。前記装置は、位相及び/または復素チャネルを決定する情報ビーム入力信号に responding して入力パイロットシンボルを決定された位相及び/または復素チャネル上に生成することによりパイロット変調シンボルを発生する変調器と、前記変調器からの前記パイロット変調シンボルを入力し、複数の商文字符中、選択された商文字符に前記パイロット変調シンボルを載搬する載搬器とを備えて、前記バーストパイロットチャネルは前記位相及び/またはチャネル及び商文字符によって前記伝送されるデータに依存する付加情報を伝送することを特徴とする。

【0009】

【発明の実施の形態】

以下、本発明の望ましい実施形態について添付図を参照しつつ詳細に説明する。下記の説明において、本発明の範囲のみを明確にする目的で、簡潔した公知機能又は構成に関する具体的な説明は省略する。

【0010】

以下、説明される本発明は QAM 変調方式を利用してデータを伝送する時、QAM 変調シンボルを復調するための必要とする変調シンボルの振幅基準 (Amplitude Reference) を提供するバーストパイロットチャネルを通じて付加情報を伝送するためのものである。前記付加情報はパケットデータ伝送に必要な情報として、例えば次のように使用される。

【0011】

一番目、相異なる多数個のパケットデータを一つのパケットデータ使用者に連続されたスロット (slot) を通じて伝送しようとする時、前記パケットデータ使用者は相異なるパケットデータを区別することが必要な情報が必要とする。この時、これを区別することが可能な情報として前記付加情報を使用することが可能である。

【0012】

二番目、パケットデータ使用者が受信したパケットデータを正確にデコーディング (decode) するのに失敗した場合、基地局に再伝送を要求し、基地局は前記再伝送要求に responding して同一のパケットデータを再伝送する。この時、再伝送されるデータは以前の伝送されたデータと同一であるにもかかわらず、符号率 (Code Rate) と変調方式を相異なるようにして伝送されることとなる。この時、初めて伝送されるデータがあるが、再伝送されるデータがあるかを区別するための前記付加情報を使用することが可能である。

【0013】

三番目、基地局は伝送されるパケットのデータ率をパケットデータ使用者に知らせるべきであるが、前記付加情報を利用してこれを知らせることも可能である。

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【0014】

送信機、前記付加情報は多数のバーストパイロットデータ使用者が送信機にバーストパイロットデータを伝送する送方向リンクのデータ率を制御する共通制御情報に使用されることになり、また前記付加情報は特定グループ、または使用者のデータ率を制御する目的にも使用されることになり、さらに、上述の場合以外に対しても付加情報ビットを利用して特定情報を伝送することになり、

【0015】

図1は本発明の実施形態によるバーストパイロットサービスのための送方向リンク送信装置の構成を示している、

【0016】

特に、前記図1の送信装置は本発明によってバーストパイロットデータ変調部 (Burst Pilot Data Modulation) 10と直交変調部 (Orthogonal Spreader) 20を含む。0シンボルが受信されると、前記バーストパイロットデータ変調部10は伝送しようとする情報ビットによってIチャネル、またはQチャネルの前記受信されたシンボルを位置させるが、または0、または1のシンボルに変換させる。変換されたシンボルは前記直交変調部20で予め設定されたバーストパイロットチャネルの直交符号 (例:ウォルシュ (Walsh) 符号) に変換されチップ単位に出力される。一方、前記変調部10ではなく前記直交変調部20を利用して付加情報を伝送する場合、前記直交変調部20で伝送する情報ビットによって予め設定された直交符号と前記付加情報を併せて伝送することになり、

【0017】

前記図1を参照すると、すべし '0' の値に構成されるフリアンブルシンボルは、信号点写像器 (Signal Point Mapper) 201に入力され '+1' にマッピング (mapping) される。前記信号点写像器201の出力シンボルは、ウォルシュ拡散器 (Walsh Spreader) 202に入力され、使用者固有のMAC識別子 (ID: Identification) (またはインデックス) に該当する特定のM-ary双直交 (M-Orthogonal) ウォルシュ符号 (またはシーケンス) により変換される。前記ウォルシュ拡散器202はIチャネルのシーケンス及びQチャネルのシーケンスを出力する。前記ウォルシュ拡散器202の出力シーケンスは、シーケンス反復器 (sequence repeater) 203に入力され伝送率 (transmission rate) によってシーケンス反復されるようになる。前記ウォルシュ拡散器202の出力シーケンスは、前記シーケンス反復器203により伝送率に応じて最大16回まで反復されることになり、従って、データトラフィックチャネル (DTCH: Data Traffic Channel) の1スロット内に含まれるバーストパイロットチャネルは、伝送率に応じて64チップ (chip) から最大1,024チップまで持続されることになり、前記シーケンス反復器203の出力 (I, Q) シーケンスは、時分割マルチプレクサ (Time Division Multiplexer) 230に入力され、前記データトラフィックチャネル及び前記バーストパイロットチャネルとマルチプレクシングされる、

【0018】

チャネルコーディングされたビットシーケンスはスクランブラ (scrambler) 211に入力されスクランブラリング (scrambling) される。前記スクランブラ211の出力シーケンスはチャネルインターリーブ (channel interleaver) 212に入力されインターリーブ (interleaving) される。この時、物理層層パケットの大きさにによって前記チャネルインターリーブ212の大きさが決定される。前記チャネルインターリーブ212の出力シーケンスはM-aryシンボル変調器 (Symbol Modulator) 213に入力されM-aryシンボルにマッピングされる。前記M-aryシンボル変調器213は伝送率に応じてQPSK (Quadrature Phase Shift Keying)、8-PSK (8-ary Phase Shift Keying)、または16-QAM (Quadrature Amplitude

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ude Modulation)変調器として動作し、可変の伝送率を有する物理階層A
 ケット単位に変調方法も変わることができ、前記M-QAMシンボル変調器213から
 出力されるM-QAMシンボルのI、Qシーケンスは、シーケンス反復/シンボル穿孔器
 (Sequence Repeater/Symbol Puncturer)214に入
 力され、伝送率によってシーケンス反復/シンボル穿孔される。前記シーケンス反復/シ
 ンボル穿孔器214から出力されるM-QAMシンボルのI、Qシーケンスは、シンボル
 デマルチプレクサ(Symbol Demultiplexer)215に入力される。
 前記シンボルデマルチプレクサ215に入力されたM-QAMシンボルのI、Qシーケ
 ンスは、データトラフィックサブチャネル(DTSCH: Data Traffic Sub
 Channel)に使用可能なN個のウォルシュ符号チャネルにデマルチプレクシング(10
 demultiplexing)され出力される。前記DTSCHに使用されるウォルシュ
 符号の個数Nは可変的であり、これに対する情報はウォルシュ空間指示サブチャネル
 (WBISCH: Walsh Space Indication Subchannel)
 を通じてブロードキャスト(broadcasting)され、移動局(MS)は
 この情報を考慮して基地局の伝送率を決定し、これを基地局に伝送する。従って、移動局
 は現在受信されたDTSCHに使用されたウォルシュ符号の割り当て状況を知ることができ
 る。N個のウォルシュ符号チャネルにデマルチプレクシングされ出力されるシンボルデ
 マルチプレクサ215の出力、I、Qシンボルはウォルシュ基数器216に入力され、チ
 ャネル別に特定ウォルシュ符号により基数される。前記ウォルシュ基数器216から出力
 されるI、Qシーケンスは、ウォルシュチャネル利得制御器(Walsh Channe
 l Gain Controller)217に入力され利得制御される。前記ウォルシュ
 チャネル利得制御器217から出力されるI、Qシーケンスは、ウォルシュチャ合算器
 (Walsh Ck. P Level Summer)218に入力されチップ単位に合算
 される。前記ウォルシュチャ合算器218から出力されるI、Qチップシーケンスは、
 前記時分割マルチプレクサ280に入力され前記バーストパイロットチャネル及びプリア
 ンプルサブチャネル(PSCH: Preamble Subchannel)とマルチプレ
 クシングされる。

【0019】

バーストパイロットデータ変調部(Burst Pilot Data Modulat
 ion, 以下、変調部)10は基本的に、入力されるパイロットチャネルデータ(a11
 0's)をツプナルマッピング(01+1, 11-1)してパイロット変調シンボルを出力す
 る。そして直交拡散部(Orthogonal Spreader)20は前記変調
 部10から出力される信号に予め設定された直交符号を乗けて直交拡散して出力する。こ
 のような処理中に、前記変調部10は入力情報ビットによって前記パイロット変調シンボ
 ルの符号(または位相)を決定して出力する。例えば、前記入力情報ビットが0であると
 、正(+)の符号を有するパイロット変調シンボルを出力し、前記入力情報ビットが1と
 あると、負(-)の符号を有するパイロット変調シンボルを出力する。

【0020】

一方、他の例として、前記変調部10は入力パイロットチャネルデータを符号マッピング
 し、前記マッピングされた信号を複素チャネル(Complex Channel)を構成
 する複数個のチャネル(Iチャネル及びQチャネル)中、入力伝送情報ビットにより選
 択されたチャネルを通じて出力する。例えば、前記入力情報ビットが0であると、Iチ
 ャネルを通じて出力し、前記入力情報ビットが1であると、Qチャネルを通じて出力する。

【0021】

このように、前記直交拡散部20は前記変調部10からのパイロット変調シンボルを予
 りバーストパイロットの初期割り当てられた複数個の直交符号中、入力情報ビットにより選
 択された所定の直交符号を有して拡散することによって付加情報を伝送することができ
 る。

【0022】

上述したような付加情報をバーストパイロットチャネルを通じて伝送する場合、前記バ
 ーストパイロットチャネルを通じて伝送される付加情報が前記バーストパイロットデータ変
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図部 10 と前記変換部 20 で、どのように表現されるかを送信機と受信機が互いに予め約束すべきである。前記バーストパイロット変換部 10 での伝送情報ビット (0 または 1) によるシンボル表現方法及び情報ビット割り当て方法は下記表 1 のようである。下記表 1 で記号 "X" は送信機と受信機との相互約束により前記シンボルの位置及び符号が固定されていることを意味する。

【表 1】

伝送情報 ビット	バーストパイロットデータ変調ブロック動作での シンボル表現方法及びシンボル当たり情報ビット割り当て			関連図
	シンボル数	シンボル出力位置	シンボル出力符号	
1	1 シンボル (128 チップ長さ)	X (0 bit/symbol)	正/負 (1 bit/symbol)	図 2A
1	1 シンボル (128 チップ長さ)	1 チャンネル/0 チャンネル (1 bit/symbol)	X (0 bit)	図 2B
2	1 シンボル (128 チップ長さ)	1 チャンネル/0 チャンネル (1 bit/symbol)	正/負 (1 bit/symbol)	図 2C
2	2 シンボル (64 チップ長さ)	X (0 bit/symbol)	正/負 (1 bit/symbol)	図 3A
2	2 シンボル (64 チップ長さ)	1 チャンネル/0 チャンネル (1 bit/symbol)	X (0 bit)	図 3B
4	2 シンボル (64 チップ長さ)	1 チャンネル/0 チャンネル (1 bit/symbol)	正/負 (1 bit/symbol)	図 3C

【0023】

図 2 はパケット (Packet) データシンボルとバーストパイロットシンボルに構成された 1.25 msec 単位のスロット (Slot) 構造の一例を示している。図示されたように、一つのスロットは 2 個の 1/2 スロット (Half Slot) に構成され、バーストパイロットシンボルは 1/2 スロットの最初の部分に 128 チップの長さを有して構成される。前記図 2 のように、128 チップのバーストパイロットシンボル 1 個が構成される場合、バーストパイロットシンボルの出力符号及び出力復調チャネルの位置によって最大 2 ビットの情報を伝送することができ、1 ビットの情報を伝送するためには、シンボルの位相 (+/-) に情報を入れる第 1 方法、または変調シンボルが出力される複素チャネルの位置を決定する第 2 方法中の一つを選択することができ、以下、説明される図 3 A 乃至図 3 C は前記図 2 のようなスロット構造の既定下で説明されたものである。

【0024】

図8Aはバーストパイロットチャネルを通じて1個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルの位相を決定することにより、1ビットの情報を伝送する場合を示す。前記パイロット変調シンボルは128チップの長さを有する。図8に示されたように、1チャネルを通じて伝送される変調シンボルの符号（または位相）に情報を乗せる。例えば、情報ビットが0であるとき、前記変調シンボルの符号を正（または負）にして伝送し、情報ビットが1であるとき、変調シンボルの符号を負（または正）にして伝送する。この方法で、1ビット（もしも）情報が伝送される。ここで、複素チャネル（ $C = \cos \theta + j \sin \theta$ ）中、1チャネルを通じて伝送される変調シンボルの位相を利用して情報を伝送する場合を説明しているが、他の例として、1チャネルの代わりに

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【0025】

図8Bはバーストパイロットチャネルを通じて1個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルが圧力される複素チャネルを決定することによって、1ビットの情報を伝送する場合を示す。

【0026】

図8Cに示されたように、情報ビットに応じて複素チャネル中、選択されたチャネル（Iチャネル、またはQチャネル）を通じて情報を伝送する方法がある。シンボルの出力符号を正（+）に予め設定し、前記選択されたチャネル上にパイロットシンボルを発生する。例えば、情報ビットが0であるとき、パイロットシンボルを複素チャネル中、Iチャネル（またはQチャネル）を通じて伝送し、情報ビットが1であるとき、パイロットシンボルをQチャネル（またはIチャネル）を通じて伝送する。この方法で、1ビット（もしも）の情報を伝送することになる。前記情報ビット値に対する出力複素チャネルは、予め固定（指定）され、変調シンボルの符号も正（+）の代わりに負（-）に予め設定して使用することになる。

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【0027】

図8Dはバーストパイロットチャネルを通じて1個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルの位相及び出力複素チャネルを指定することにより、2ビットの情報を伝送する場合を示す。これは前記図8Aと図8Bの方法を組み合わせた場合である。

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【0028】

図示されたように、1番目情報ビットに対応して変調シンボルの符号（または出力複素チャネル）を決定し、2番目情報ビットに対応して前記変調シンボルの出力複素チャネル（または位相）を決定する方法がある。例えば、2情報ビットを伝送する場合、伝送される2情報ビット中、1番目情報ビットが0であるとき、変調シンボルの符号を正（または負）にして伝送し、1番目情報ビットが1であるとき、変調シンボルの符号を負（または正）にして伝送する。そして、2番目情報ビットが0であるとき、パイロット変調シンボルを複素チャネル中、Iチャネル（またはQチャネル）を通じて伝送し、2番目情報ビットが1

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【0029】

他の例として、伝送される2ビット情報中、1番目情報ビットが0であるとき、パイロット変調シンボルを複素チャネル中、Iチャネル（またはQチャネル）を通じて伝送し、1番目情報ビットが1であるとき、前記パイロット変調シンボルをQチャネル（またはIチャネル）を通じて伝送する。2番目情報ビットが0であるとき、前記パイロット変調シンボルの符号を正（または負）にして伝送し、2番目情報ビットが1であるとき、前記パイロット変調シンボルの符号を負（または正）にして伝送する。

【0030】

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図4はパケット(PACKET)データシンボルとバーストパイロットシンボルに構成された1.25msのS/C単位のスロット(SLOT)構成の他の例を示している。図示されたように、一つのスロットは2個の1/2スロットに構成され、各バーストパイロットチャネルは1/2スロットの初めの部分に位置した64チャップの2個の連続されたバーストパイロットシンボルに構成される。前記図4のように、64チャップのバーストパイロットシンボル2個が構成される場合、パイロット変調シンボルの符号(または位相)及び変調シンボルを伝送する複製チャネルの選択を逐次最大4ビットの情報を伝送することができる。以下、説明される図5A乃至図5Cは前記図4のようなスロット構成の例に基づいて説明されたものである。

【0031】

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図5Aはバーストパイロットチャネルを通じて2個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルそれぞれに対して位相を決定することによって2ビットの情報を伝送する場合を示す。前記パイロット変調シンボルは64チャップの長さを有する。

【0032】

図示されたように、1/2スロットの初めの部分に64チャップのバーストパイロットシンボル2個が構成された場合、2個のパイロット変調シンボルそれぞれの符号(または位相)を伝送される情報ビットによって決定して伝送する。ここで、パイロット変調シンボルを複製チャネル中、1チャネルのみ利用して伝送するものによって決定する。例えば、2個の情報ビット中、一番目情報ビットが0であると、一番目パイロット変調シンボルの符号を正(または真)にして伝送し、一番目情報ビットが1であると、変調シンボルの符号を真(または正)にして伝送する。二番目情報ビットが0であると、二番目パイロット変調シンボルの符号を正(または真)にして伝送し、二番目情報ビットが1であると、前記パイロット変調シンボルの符号を真(または正)にして伝送する。即ち、一つのパイロット変調シンボル当たり1ビットの情報を伝送するので、2個のパイロット変調シンボル区間(1.25チャップ)間、2個の情報ビットを伝送することができる。前記情報ビットの値による変調シンボルの位相は、予約記(+)、または真(-)によって決定して採用する。例えば、情報ビットが0であると正(+), 情報ビットが1であると真(-)に設定されること

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【0033】

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図5Bはバーストパイロットチャネルを通じて2個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルそれぞれに対して出力複製チャネルを決定することにより、2ビットの情報を伝送する場合を示す。

【0034】

図示されたように、2個のパイロット変調シンボルそれぞれに対して出力複製チャネルを分離して決定することにより情報ビットを伝送する。例えば、2個の情報ビット中、一番目情報ビットが0であると、一番目パイロット変調シンボルをIチャネル(またはQチャネル)を通じて伝送し、一番目情報ビットが1であると、前記一番目パイロット変調シンボルをQチャネル(またはIチャネル)を通じて伝送する。また、二番目情報ビットが0であると、二番目パイロット変調シンボルをIチャネル(またはQチャネル)を通じて伝送し、二番目情報ビットが1であると、前記二番目パイロット変調シンボルをQチャネル(またはIチャネル)を通じて伝送する。即ち、一つのパイロット変調シンボル当たり1個の情報ビットを64チャップ区間の間伝送するので、2個のパイロット変調シンボル区間(1.25チャップ)間、2個の情報ビットを伝送すること

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【0035】

図5Cはバーストパイロットチャネルを通じて2個のパイロット変調シンボルが伝送される場合、前記パイロット変調シンボルそれぞれに対して位相及び出力複製チャネルを決定することにより、4ビットの情報を伝送する場合を示す。前記パイロット変調シンボルは64チャップの長さを有する。これは前記図5Aと図5Bの方法を組み合わせた場合である。

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【0036】

図5Cに示されたように、パイロット変調シンボルの符号（または振幅）及び複素チャネルを決定することによって、4ビットの情報を伝送している。ここで、情報ビットの値による変調シンボルの符号及び複素チャネルは予め決定して使用される。例えば、4ビットの情報ビットを伝送する場合、前記4ビットの情報ビット中、一番目情報ビットによって一番目パイロット変調シンボルの符号を負（-）、または正（+）にして伝送し、二番目情報ビットによって前記一番目パイロット変調シンボルの複素チャネル中、Iチャネル、またはQチャネルを通じて伝送する。そして、三番目情報ビットによって二番目パイロット変調シンボルの符号を負、または正に伝送し、四番目情報ビットによって前記二番目パイロット変調シンボルのI、またはQチャネルを通じて伝送する。

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【0037】

一方、前記のように変調部10ではなく、復調部20を使用して付加情報を伝送することもできる。一般的に、前記変調部10で出力される変調シンボルの復調部20で入力される。前記復調部20はバーストパイロット変調シンボルの符号チャネル（code channel）と区分するために、所定の置換符号（例：ウォルシュ符号）に置換させる。前記バーストパイロットチャネルのために予め定義した置換符号の数が1個あると、付加情報を伝送することになる。しかし、前記置換符号を2個使用すると、1ビットの情報を伝送することになる。もし、前記変調部10で出力されるバーストパイロット変調シンボルの2ⁿ個の置換符号中、一つを選択して置換する場合には、nビットの情報を伝送することになる。ここで、2ⁿ個の置換符号は送信機と受信機が事前に使用可能なものであると約束されているべきである。

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【0038】

図6A乃至図6Dは本発明の他の実施形態によるバーストパイロットチャネルの置換符号を利用して付加情報を伝送する方法を示す。

【0039】

前記図6Aはバーストパイロットチャネルを通じて1個のパイロット変調シンボルの符号を伝送する場合、バーストパイロット変調部10で出力されるパイロット変調シンボルの2個の置換符号中、伝送情報ビットによって選択された一つの置換符号により置換するものを示す。2個の置換符号中のいずれかを使用する場合は伝送情報ビットにより決定される。一つの変調シンボルの128チップに置換させるために「番目」と「番目インデックス（index）」を有する置換符号をそれぞれW（128、i）とW（128、j）と定義する時、伝送しようとする情報ビットが0である場合、前記復調部20は前記変調部10からの出力変調シンボルのW（128、i）（またはW（128、j））に置換させ、伝送しようとする情報ビットが1である場合、W（128、j）（またはW（128、i））に置換させ1ビットの情報を伝送する。

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【0040】

ここで、2ⁿ個の置換符号中、一つを選択して置換すると、nビットの情報を伝送することになる。図6Aの方法と共に使用すると、n+1個の情報ビットを伝送することになる。同様に、図6Bの方法と共に使用すると、n+1個の情報ビットを伝送することになる。また図6Cの方法と共に使用すると、n+2個の情報ビットを伝送することになる。これは、前記図6Cに示したように変調部10はパイロット変調シンボルの2個の情報ビットを乗せることになり、前記のように置換方式によりn個の情報ビットをさらに乗せることになり得るためである。


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【0041】

前記図6Bはバーストパイロットチャネルを通じて2個のパイロット変調シンボルの符号を伝送する場合、バーストパイロット変調部10で出力される2個のパイロット変調シンボルのそれぞれ2個の置換符号中、伝送情報ビットによって選択された一つの置換符号を有して置換することになる。ここで、前記変調部10で出力される変調シンボルの64チップ置換符号の置換符号により置換される。1番目と2番目インデックス（index）を有する置換符号をそれぞれW（64、i）とW（64、j）とし、2個の情報ビットを伝送しよう

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- 213 M-DMZシンボル変換器
- 214 シーケンス戻り/シンボル変換器
- 215 シンボルデマルチプレクサ
- 217 ウォルシュチャネル利得制御器
- 218 ウォルシュチャップ合算器
- 230 時分割マルチプレクサ

WO 02/33841 A1 

This patent is published with abstracts, which are filed
under the name of the inventor and the inventor's legal
representative in accordance with the provisions of the Patent
Act of the Republic of Korea.

FIG. 1

FIG. 2

**APPARATUS AND METHOD FOR TRANSMITTING A BEST
PILOT CHANNEL IN A MOBILE COMMUNICATION SYSTEM**

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a mobile communication system, and in particular, to an apparatus and method for transmitting information over a pilot channel.

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2. Description of the Related Art

Recently, a mobile communication system supporting not only a voice service but also a high-speed packet data service has been proposed to meet the growing requirement for high-speed data transmission. In the mobile communication system supporting the high-speed packet data transmission, a transmitter performs QAM (Quadrature Amplitude Modulation) on transmitted packet data. Further, the transmitter transmits a time-division-multiplexed pilot channel and a time-division-multiplexed burst pilot channel.

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Generally, a phase modulation scheme such as QPSK (Quadrature Phase Shift Keying) includes information in a phase component of a modulated symbol. Therefore, a receiver demodulates the modulated symbol by utilizing the common pilot channel as a phase reference signal. However, a QAM scheme includes information in magnitude and phase components of the modulated symbol. For example, when the system supporting the high-speed data transmission employs 16-QAM (16-ary QAM) or 64-QAM (64-ary QAM) for packet data transmission, the receiver requires an amplitude reference of a demodulated symbol in order to correctly demodulate the information included in the modulated symbol. Therefore, the transmitter must transmit both a phase reference signal and an amplitude reference signal of the modulated symbol. That is, when the transmitter employing the QAM modulation transmits data at constant transmission power, the common pilot channel can be used as both the phase reference and the amplitude reference. However, when the transmission power varies at stated periods, a reference

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Reference

DESCRIPTION

- 1 -

signal providing an amplitude reference of the QAM-modulated symbol is required. To provide the amplitude reference of the QAM-modulated symbol, the burst pilot channel is typically used. The burst pilot channel is used to provide only the amplitude reference of the QAM-modulated symbol. Generally, it is most important for the mobile communication system to efficiently utilize the limited radio resources. To this end, many multi-
 5 detection schemes have been proposed. Although the burst pilot channel is used to provide the amplitude reference of the modulated signal, it can also provide other side information (or additional information), thus contributing
 10 to its efficient utilization.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide an apparatus and method for transmitting side information using a burst pilot channel providing an amplitude reference of a modulated symbol.

It is another object of the present invention to provide an apparatus and method for transmitting side information using a phase component of a modulated burst pilot symbol providing an amplitude reference of a modulated symbol.

It is further another object of the present invention to provide an apparatus and method for transmitting side information using a complex output channel for a modulated burst pilot symbol providing an amplitude reference of a modulated symbol.

It is yet another object of the present invention to provide an apparatus and method for transmitting side information using a spreading code for a modulated burst pilot symbol providing an amplitude reference of a modulated symbol.

To achieve the above and other objects, there is provided an apparatus for transmitting a time-discontinuous burst pilot channel being dependent on transmission data in a mobile communication system. In the apparatus, a modulator generates a modulated pilot symbol by generating an

FIG. 1

FIG. 2

FIG. 3

input pilot symbol in a designated phase and/or on a designated complex channel in response to an information bit input signal for designating the phase before the complex channel, and a spreader spreads the modulated pilot symbol from the modulator with an orthogonal code selected among a plurality of orthogonal codes. The burst pilot channel transmits side information being dependent on the transmission data according to the phase, and/or the channel and the orthogonal code.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates a structure of a forward link transmitter for a packet data service according to an embodiment of the present invention;

FIG. 2 illustrates a structure of a 1.25 msec slot comprised of packet data symbols and burst pilot symbols;

FIGs. 3A, 3B, and 3C illustrate various methods of transmitting side information using one modulated pilot symbol transmitted over a burst pilot channel according to an embodiment of the present invention;

FIG. 4 illustrates another structure of a 1.25 msec slot comprised of packet data symbols and burst pilot symbols;

FIGs. 5A, 5B, and 5C illustrate various methods of transmitting side information using two modulated pilot symbols transmitted over a burst pilot channel according to an embodiment of the present invention; and

FIGs. 6A and 6B illustrate various methods of transmitting side information using a spreading code for a modulated burst pilot symbol according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well known functions or constructions are not described in detail since they would obscure the invention in unnecessary detail.

FIG. 1

FIG. 1

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The present invention transmits side information over a burst pipe channel providing an amplitude reference of a modulated symbol, required for demodulating the QAM-modulated symbol received from a transmitter. The side information is required for packet data transmission, as follows:

- 5 (1) When a plurality of different packet data are transmitted to a packet data user over consecutive slots, the packet data user requires information to indicate the different packet data. The side information can be used to provide this information.
- 10 (2) Upon failure to correctly decode received packet data, the packet data user sends a retransmission request to a base station, and the base station data retransmits the same packet data in response to the retransmission request. The retransmitted data, though identical to the previously transmitted data, may be transmitted at a different code rate in a different modulation mode. The side information can be used to indicate whether to be first transmission data and to be retransmission data.
- 15 (3) The base station user informs the packet data user of a data rate of the packets being transmitted, the side information can be used to provide the data rate.
- 20 (4) The side information can be used as common control information for controlling a data rate of a reverse link used by a plurality of packet data users to transmit packet data to the base station. Further, the side information can also be used to control a data rate of a specific group or user. In addition, the side information can also be used to transmit specific information even in a case other than the above-stated cases.
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FIG. 1 illustrates a structure of a forward link transmitter for a packet data service according to an embodiment of the present invention. Particularly, the transmitter shown in FIG. 1 includes a burst pipe data modulator 10 and an orthogonal spreader (or Walsh code generator) 20 according to the present invention. Upon receiving a symbol of '0', the burst pipe data modulator 10 performs the received symbol in as I channel or a Q channel according to an information bit to be transmitted, or converts the received symbol to a symbol of '0' or '1'. The converted symbol is spread with a predefined orthogonal code (e.g., Walsh code) for the burst pipe channel by the orthogonal spreader 20, and then, output as a chip rate. When

FIG. 10

FIG. 10 (continued)

- 5 -

converting side information using the orthogonal spreader 20 before the burst pilot data modulator 10, the orthogonal spreader 20 can multiply the side information by an orthogonal code, which is previously determined according to the information bit to be transmitted.

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Referring to FIG. 1, input presymbol symbols of all N 's are mapped to $'+1'$ by a signal point mapper 201. The output symbols of the signal point mapper 201 are spread by a Walsh spreader 202 with a specific 66-ary biorthogonal Walsh code (or sequence) associated with a user's unique MAC ID (identification or index). The Walsh spreader 202 outputs an I-channel sequence and a Q-channel sequence. The output sequences of the Walsh spreader 202 are provided to a sequence repeater 203 where they are subject to sequence repetition according to a transmission rate (or data rate). The output sequences of the Walsh spreader 202 can be repeated by the sequence repeater 203 as many as a maximum of 16 times according to the transmission rates. Therefore, the burst pilot channel included in one slot of a data traffic channel (DTCH) can continue for 64 chips to 1,024 chips according to the transmission rates. The I and Q-channel sequences output from the sequence repeater 203 are provided to a time division multiplexer (TDM) 204 where they are multiplexed with the data traffic channel and the burst pilot channel.

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An input channel-coded bit sequence is scrambled by a scrambler 211, and then, interleaved by a channel interleaver 212. The size of the channel interleaver 212 depends on the size of a physical layer packet. The output sequence of the channel interleaver 212 is mapped to M-ary symbols by an M-ary symbol modulator 213. The M-ary symbol modulator 213 serves as the QPSK (Quadrature Phase Shift Keying), 8-PSK (8-ary Phase Shift Keying) or 16-QAM (Quadrature Amplitude Modulation) modulator according to the transmission rates, and it is also possible to change the modulation mode in a unit of the physical layer packet having a variable transmission rate. The I and Q sequences of the M-ary symbols output from the M-ary symbol modulator 213 are subjected to sequence repetition/symbol puncturing according to the transmission rate in a sequence repeats/symbol puncturer 214. The I and Q sequences of the M-ary symbols output from the sequence repeats/symbol puncturer 214 are

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FIG. 10

FIG. 10

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provided to a symbol demultiplexer (DEMUX) 215 where they are demultiplexed into N Walsh code channels available for data traffic sub-channels (DTSCHs). The number, N, of the Walsh codes used for the DTSCHs is variable; this information is broadcast over a Walsh space indication sub-channel (WISCH), and a mobile station (MS) determines a transmission rate of a base station (BS), considering the received information, and then sends the determined transmission rate information to the base station. Therefore, the mobile station can determine which Walsh codes are assigned to the currently received DTSCH. The I and Q sequences, demultiplexed into N Walsh code channels, output from the symbol demultiplexer 215 are provided to a Walsh spreader for a Walsh code generator 216 where they are spread with a specific Walsh code according to the respective channels. The I and Q sequences output from the Walsh spreader 216 are gain-controlled by a Walsh channel gain controller 217. The I and Q sequences output from the Walsh channel gain controller 217 are summed up in a chip rate by a Walsh chip level summer 218. The I and Q chip sequences output from the Walsh chip level summer 218 are provided to the time division multiplexer 220 where they are multiplexed with the burst pilot channel (BPCB) and a preamble sub-channel (PSCB).

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The burst pilot data modulator 10 (hereinafter, referred to as "modulator") for simplicity performs signal mapping (0→+1, 1→-1) on the input pilot channel data of all "0"s, and outputs modulated pilot symbols. The orthogonal spreader 20 orthogonally spreads the signals output from the modulator 10 by multiplying the modulated pilot symbols by a predefined orthogonal code. In this process, the modulator 10 detects a sign for phase of the modulated pilot symbols according to the input information bit. For example, the modulator 10 outputs a modulated pilot symbol having a positive sign (+) for the input information bit of "0", and a modulated pilot symbol having a negative sign (-) for the input information bit of "1".

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As another example, the modulator 10 performs signal mapping on the input pilot channel data, and outputs the mapped signal through a channel selected according to the input transmission information bit, among a plurality of channels (I channel and Q channel) constituting complex objects. For example, the modulator 10 outputs its output signal through

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FIG. 10

FIG. 10

be I channel for the input information bit of '0', and through the Q channel for the input information bit of '1'.

In an alternative embodiment, the orthogonal spreader 20 can transmit the side information by spreading the modulated pilot symbol output from the modulator 10 with a specific orthogonal code selected according to the input information bit, among a plurality of orthogonal codes previously assigned for the burst pilot.

When the side information is transmitted over the burst pilot channel as stated above, a method for expressing the side information transmitted over the burst pilot channel by the burst pilot data modulator 10 and the orthogonal spreader 20 should be previously agreed between the transmitter and the receiver. Table 1 shows a method for expressing symbols selected according to the transmission information bit (0 or 1) and a method for assigning the information bit by the burst pilot data modulator 10. In Table 1, 'N' indicates that the position and the sign of the symbol are fixed according to the agreement between the transmitter and the receiver.

Table 1

Tx Info Bits	Method of Expressing Symbols and Assigning Info Bits Per Symbol by Burst Pilot Data Modulator			Related Drawing
	Symbol Form.	Symbol output Pos.	Symbol output Sign.	
1	1 symbol (1 2N-chip length)	X (0 bit/symbol)	Positive/Negative (1 bit/symbol)	FIG. 5A
1	1 symbol (1 2N-chip length)	I channel/Q channel (1 bit/symbol)	X (0 bit)	FIG. 1B
2	1 symbol (1 2N-chip length)	I channel/Q channel (1 bit/symbol)	Positive/Negative (1 bit/symbol)	FIG. 1C
2	2 symbols (2N-chip)	X (0 bit/symbol)	Positive/Negative (1 bit/symbol)	FIG. 5A

Reference

FIG. 3A(1)

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	length			
2	2 symbols (64-chip length)	1 channel/Q channel (1 bit/symbol)	K (6 bit)	FIG. 5B
4	2 symbols (64-chip length)	1 channel/Q channel (1 bit/symbol)	Y-axis/bit/cell on (1 bit/symbol)	FIG. 5C

FIG. 3 illustrates a structure of a 1.25ms slot comprised of packet data symbols and burst pilot symbols. As illustrated, one slot is comprised of two half slots, and the burst pilot symbol is positioned in a leading 128-chip part of each half slot. When one 128-chip burst pilot symbol is transmitted as shown in FIG. 3, it is possible to transmit a maximum of 3 information bits according to a sign of the output burst pilot symbol and a position of the complex output channel. In order to transmit one information bit, it is possible to select one method out of a first method for loading the information on a phase ($\pm\pi/2$) of the symbol and a second method for designating a position of the complex channel for outputting the modulated symbol. A description of FIGs. 3A to 5C will be given under the assumption that the slot has the structure shown in FIG. 3.

FIG. 3A illustrates a method for transmitting one information bit by designating a phase of one modulated pilot symbol transmitted over a burst pilot channel. The modulated pilot symbol has a length of 128 chips. As illustrated in FIG. 3A, information is loaded on a sign (or phase) of a modulated symbol transmitted over the I channel. For example, the modulated symbol is transmitted with a positive sign (or negative sign) for the information bit of "0", while the modulated symbol is transmitted with a negative sign (or positive sign) for the information bit of "1". In this manner, the one information bit is transmitted. Although the description has been made of the method for transmitting information using a phase of the modulated symbol transmitted over the I channel out of the complex channel, it is also possible to transmit the information using a phase of a modulated symbol transmitted over the Q channel rather than the I channel. The phase of the modulated symbol, associated with the information bit value, is previously fixed (or designated).

SUMMARY

DESCRIPTION

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FIG. 3B illustrates a method for transmitting one information bit by designating one channel out of complex channels for outputting one modulated pilot symbol transmitted over the base pilot channel. As illustrated in FIG. 3B, information is transmitted through a selected channel (I channel or Q channel) out of the complex channels according to the information bit. An output sign of the symbol is preset to a positive value (+), and then, the pilot symbol is generated on the selected channel. For example, the pilot symbol is transmitted through the I channel (or Q channel) out of the complex channels for the information bit of "0", while the pilot symbol is transmitted through the Q channel (or I channel) for the information bit of "1". In this manner, it is possible to transmit the one information bit. The complex output channel for the information bit is previously fixed (designated). It is also possible to previously set the sign of the modulated symbol to a negative value (-) rather than a positive value (+).

FIG. 3C illustrates a method for transmitting two information bits by designating a phase of one modulated pilot symbol transmitted over a base pilot channel and also designating a complex output channel for the modulated pilot symbol. This method is a combination of the methods of FIGs. 3A and 3B. As illustrated, a sign (or complex output channel) of a modulated symbol is designated in association with a first information bit, and a complex output channel (or phase) of the modulated symbol is designated in association with a second information bit. For example, if a first information bit out of the two information bits to be transmitted is "0", the modulated symbol is transmitted with a positive sign (or negative sign). Otherwise, if the first information bit is "1", the modulated symbol is transmitted with a negative sign (or positive sign). In addition, if a second information bit out of the two transmission information bits is "0", the modulated pilot symbol is transmitted through the I channel (or Q channel) out of the complex channels. Otherwise, if the second information bit is "1", the modulated pilot symbol is transmitted through the Q channel (or I channel) of the complex channels.

As another example, if the first information bit of the two transmission information bits is "0", the modulated pilot symbol is

FIG. 3A

FIG. 3B

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transmitted through the I channel (or Q channel). If the first information bit is '1', the modulated pilot symbol is transmitted through the Q channel (or I channel). If the second information bit is '0', the modulated pilot symbol is transmitted with a positive sign (or negative sign). If the second information bit is '1', the modulated pilot symbol is transmitted with a negative sign (or positive sign).

FIG. 4 illustrates another structure of a 1.25μsec slot comprised of packet data symbols and burst pilot symbols. As illustrated, one slot is comprised of two half slots, and each burst pilot channel is comprised of two consecutive 64-chip burst pilot symbols positioned in a leading part of each half slot. When two 64-chip burst pilot symbols are concatenated as shown in FIG. 4, it is possible to transmit a maximum of 4 information bits by selecting a sign (or phase) of the modulated pilot symbols and selecting a complex channel for transmitting the modulated symbols. A description of FIGs. 5A to 5C will be given under the assumption that the slot has the structure illustrated in FIG. 4.

FIG. 5A illustrates a method for transmitting 2 information bits by separately designating a phase of two modulated pilot symbols transmitted over a burst pilot channel. The modulated pilot symbol has a length of 64 chips. As illustrated, the information bits are transmitted by separately designating a sign (or phase) of the two 64-chip modulated pilot symbols positioned in the leading part of each half slot. Here, it is assumed that the modulated pilot symbols are transmitted through only the I channel out of the complex channels. For example, if the first information bit out of the two information bits is '0', the first modulated pilot symbol is transmitted with a positive sign (or negative sign). If the first information bit is '1', the first modulated pilot symbol is transmitted with a negative sign (or positive sign). In addition, if the second information bit of the two information bits is '0', the second modulated pilot symbol is transmitted with a positive sign (or negative sign). If the second information bit is '1', the second modulated pilot symbol is transmitted with a negative sign (or positive sign). Thus, one information bit is transmitted per one modulated pilot symbol, so that it is possible to transmit two information bits for a 128-chip period of the two modulated pilot symbols. The phase of the modulated symbols, which is

FIG. 5B

FIG. 5C

associated with the information bit values, are previously fixed to a positive value (+) or a negative value (-). For example, the phase can be fixed to a positive value (+) for the information bit of '0', and a negative value (-) for the information bit of '1'.

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 FIG. 5B illustrates a method for transmitting two information bits by separately designating a complex output channel for two modulated pilot symbols transmitted over the same pilot channel. As illustrated, the information bits are transmitted by separately designating a complex output channel for the two modulated pilot symbols. For example, if the first information bit of the two information bits is '0', the first modulated pilot symbol is transmitted through the I channel (or Q channel). If the first information bit is '1', the first modulated pilot symbol is transmitted through the Q channel (or I channel). In addition, if the second information bit of the two information bits is '0', the second modulated pilot symbol is transmitted through the I channel (or Q channel). If the second information bit is '1', the second modulated pilot symbol is transmitted through the Q channel (or I channel). That is, one information bit is transmitted per one modulated pilot symbol for a 64-chip period, so that it is possible to transmit two information bits for a 128-chip period of the two modulated pilot symbols.

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FIG. 5C illustrates a method for transmitting four information bits by separately designating a phase of two modulated pilot symbols transmitted over a same pilot channel and also separately designating a complex output channel for the modulated pilot symbols. The modulated pilot symbols has a length of 64 chips. This method is a combination of the methods of FIGs. 5A and 5B. As illustrated in FIG. 5C, four information bits are transmitted by designating a sign (or phase) of the modulated pilot symbol and also designating an complex output channel for the modulated pilot symbol. Here, the sign and the complex channel of the modulated symbols, which are associated with the information bit values, are previously designated. For example, to transmit 4 information bits, the first modulated pilot symbol is transmitted with a negative sign (-) or a positive sign (+) according to the first information bit of the four information bits, and the first modulated pilot symbol is transmitted through the I channel or the Q channel of the complex channels according to the second information bit. In

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FIG. 6A

FIG. 6B

-12-

in addition, the second modulated pilot symbol is transmitted with a negative sign (-) or a positive sign (+) according to the third information bit, and the second modulated pilot symbol is transmitted through the I channel or the Q channel of the complex channel according to the fourth information bit.

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In an alternative embodiment, it is also possible to transmit the side information using the orthogonal spreader 20, rather than the modulator 19. The modulated symbols output from the modulator 19 are provided to the orthogonal spreader 20. The orthogonal spreader 20 spreads the modulated symbols with a predetermined orthogonal code (e.g., Walsh code) in order to distinguish the modulated burst pilot symbols from other code channels. If the number of the predetermined orthogonal codes for the burst pilot channel is one, it is not possible to transmit the side information. However, when two orthogonal codes are used, it is possible to transmit one information bit. If the modulated burst pilot symbols output from the modulator 19 are spread with a selected one of 2ⁿ orthogonal codes, it is possible to transmit n information bits. In this case, it should be previously agreed between the mobile station and the base station that there are 2ⁿ available orthogonal codes.

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FIGs. 6A and 6B illustrate a method for transmitting side information using spreading codes for a burst pilot channel according to different embodiments of the present invention. Specifically, FIG. 6A illustrates a method for transmitting one modulated pilot symbol over the burst pilot channel, wherein the modulated pilot symbols output from the burst pilot data modulator 19 are spread with an orthogonal code selected according to the transmission information bit, out of two orthogonal codes. Which orthogonal code is to be selected out of the two orthogonal codes is determined according to the transmission information bit. When orthogonal codes having 1st and 2nd indexes for spreading one modulated symbol into 128 chips are defined as W(128,i) and W(128,j), respectively, the orthogonal spreader 20 spreads the modulated symbol output from the modulator 19 with W(128,i) (or W(128,j)) for the transmission information bit of '0', and spreads the modulated symbol with W(128,i) (or W(128,j)) for the transmission information bit of '1', thereby transmitting one information bit.

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FIG. 5B

FIG. 5B

(2)

In this manner, it is possible to transmit n information bits by alternately selecting one of the 2^2 orthogonal codes for spreading. When used along with the methods of FIG. 3A and FIG. 3B, this scheme can transmit $(2+1)$ information bits. Further, when used along with the method of FIG. 3C, this scheme can transmit $(2+2)$ information bits, because the modulator 10 can load two information bits on the modulated pilot symbols as shown in FIG. 3C and then n information bits can be further loaded by the above-mentioned spreading code selecting method.

FIG. 6B illustrates a method for transmitting two modulated pilot symbols over the burst pilot channel, wherein the two modulated pilot symbols output from the burst pilot data modulator 10 are spread with an orthogonal code selected according to the transmission information bit, one of two orthogonal codes. The modulated symbols output from the modulator 10 are spread with a 64-chip orthogonal code. When orthogonal codes having 1^{st} and 2^{nd} indices for spreading one modulated symbol into 64 chips are defined as $W(64,1)$ and $W(64,2)$, respectively, the orthogonal spreader 20, in transmit two information bits, spreads the first modulated symbol output from the modulator 10 with $W(64,1)$ (or $W(64,2)$) for the first information bit of '0', and spreads the first modulated symbol with $W(64,1)$ (or $W(64,1)$) for the first information bit of '1', thereby transmitting one information bit. In addition, the orthogonal spreader 20 spreads the second modulated symbol output from the modulator 10 with $W(64,1)$ (or $W(64,2)$) for the second information bit of '0', and spreads the second modulated symbol with $W(64,2)$ (or $W(64,2)$) for the second information bit of '1', thereby transmitting one information bit.

In this way, it is possible to transmit $2n$ information bits by alternately selecting one of the 2^2 orthogonal codes for spreading. When used along with the methods of FIG. 5A and FIG. 5B, this scheme can transmit $(2n+2)$ information bits. Further, when used along with the method of FIG. 5C, this scheme can transmit $(2n+4)$ information bits.

As described above, the apparatus and method according to the present invention can transmit side information as well as amplitude reference for demodulation over the burst pilot channel according to the

FIG. 10

FIG. 10

FIG. 10

number of modulated pilot symbols transmitted over the burst pilot channel, the complex elements for transmitting the modulated pilot symbols, the sign of the modulated pilot symbols, and the number of the orthogonal spreading codes used for the pilot channel.

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While the invention has been shown and described with reference to a certain preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

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要約

要約

- 15 -

WHAT IS CLAIMED IS:

- 1. An apparatus for transmitting a data-dependent base pilot channel dependent on transmission data in a mobile communication system, comprising:
 - a modulator for generating a modulated pilot symbol by outputting an input pilot channel data at at least one of a designated phase and on a designated complex channel according to an information bit for designating at least one of the phase and the complex channel; and
 - a spreader for spreading the modulated pilot symbol from the modulator with an orthogonal code selected among a plurality of orthogonal codes;
 wherein the base pilot channel transmits side information being dependent on the transmission data according to at least one of the phase, and the complex channel and the orthogonal code.
- 2. The apparatus as claimed in claim 1, wherein the modulated pilot symbol has a length of 128 chips.
- 3. The apparatus as claimed in claim 1, wherein the modulated pilot symbol has a length of 64 chips.
- 4. The apparatus as claimed in claim 1, wherein the complex channel includes an I channel and a Q channel.
- 5. An apparatus for transmitting side information over a base pilot channel in a mobile communication system, comprising:
 - a modulator for generating a modulated pilot symbol by outputting an input pilot channel data at a designated phase according to an information bit for designating the phase; and
 - a spreader for spreading a modulated pilot symbol output from the modulator with a predetermined orthogonal code.
- 6. An apparatus for transmitting side information over a base pilot channel in a mobile communication system, comprising:
 - a modulator for generating a modulated pilot symbol by outputting

要約

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an input pilot channel data to a designated complex channel according to an information bit for determining the complex channel; and
 a spreader for spreading a modulated pilot symbol output from the modulator with a predefined orthogonal code.

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7. An apparatus for transmitting side information over a burst pilot channel in a mobile communication system, comprising:
 a modulator for generating a burst pilot symbol; and
 a spreader for spreading the burst pilot symbol with an orthogonal code selected according to an information bit, from a plurality of orthogonal codes.

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8. An apparatus for transmitting side information over a burst pilot channel in a mobile communication system, comprising:
 a modulator for generating a modulated pilot symbol by outputting an input pilot channel data as a designated phase according to an information bit for designating the phase; and
 a spreader for spreading the modulated pilot symbol with an orthogonal code selected according to the information bit, from a plurality of orthogonal codes.

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9. An apparatus for transmitting side information over a burst pilot channel in a mobile communication system, comprising:
 a modulator for generating a modulated pilot symbol by outputting an input pilot channel data to a designated complex channel according to an information bit for determining the complex channel; and
 a spreader for spreading the modulated pilot symbol with an orthogonal code selected according to the information bit, from a plurality of orthogonal codes.

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10. A method for transmitting a time-discontinuous burst pilot channel dependent on transmission data in a mobile communication system, comprising the steps of:
 generating a modulated pilot symbol by outputting an input pilot symbol at at least one of a designated phase and on a designated complex channel according to an information bit for determining at least one of the

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要約

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phase and the complex channel, and
 spreading the modulated pilot symbol with an orthogonal code
 selected from a plurality of orthogonal codes,
 wherein the base pilot channel transmits side information being
 dependent on the transmission data according to the phase, and/or the
 complex channel and the orthogonal code.

11. The method as claimed in claim 10, wherein the modulated
 pilot symbol has a length of 128 chips.

12. The method as claimed in claim 10, wherein the modulated
 pilot symbol has a length of 64 chips.

13. The method as claimed in claim 10, wherein the complex
 channel includes an I channel and a Q channel.

14. A method for transmitting side information over a base pilot
 channel in a mobile communication system, comprising the steps of:
 generating a modulated pilot symbol by outputting an input pilot
 symbol at a designated phase according to an information bit, the
 determining the phase; and
 spreading the generated modulated pilot symbol with a predefined
 orthogonal code.

15. A method for transmitting side information over a base pilot
 channel in a mobile communication system, comprising the steps of:
 generating a modulated pilot symbol by outputting an input pilot
 symbol on a designated complex channel according to an information bit, the
 determining the complex channel; and
 spreading the generated modulated pilot symbol with a predefined
 orthogonal code.

16. A method for transmitting side information over a base pilot
 channel in a mobile communication system, comprising the steps of:
 generating a pilot symbol; and
 spreading the generated pilot symbol with an orthogonal code.

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selected according to an information bit, from a plurality of orthogonal codes.

17. A method for transmitting side information over a burst pilot channel in a mobile communication system, comprising the steps of:
5 generating a modulated pilot symbol by outputting an input pilot symbol at a designated phase according to an information bit for determining the phase; and
10 spreading the generated modulated pilot symbol with an orthogonal code selected according to the information bit input signal, from a plurality of orthogonal codes.

18. A method for transmitting side information over a burst pilot channel in a mobile communication system, comprising the steps of:
15 generating a modulated pilot symbol by outputting an input pilot symbol as a designated complex channel according to an information bit for determining the complex channel; and
20 spreading the generated modulated pilot symbol with an orthogonal code selected according to the information bit, from a plurality of orthogonal codes.

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FIG. 2

DESCRIPTION

DESCRIPTION

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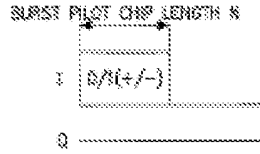


FIG. 3A

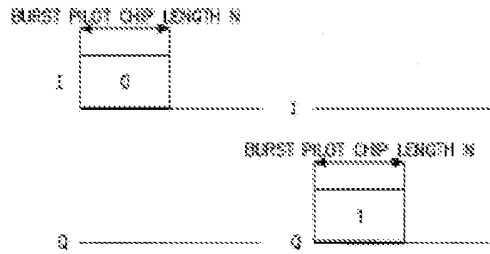


FIG. 3B

FIG. 3C

FIG. 3C

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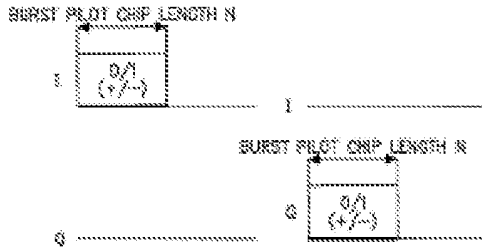


FIG. 3C

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FIG. 4

DESCRIPTION

DESCRIPTION

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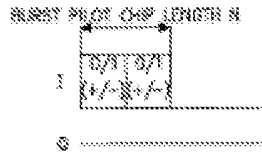


FIG. 5A

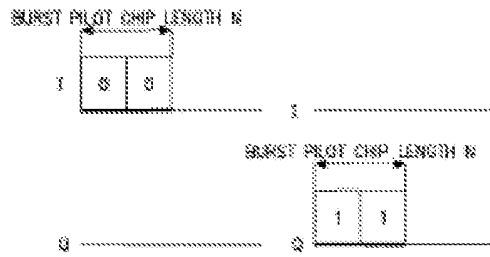


FIG. 5B

FIG. 6A

FIG. 6A

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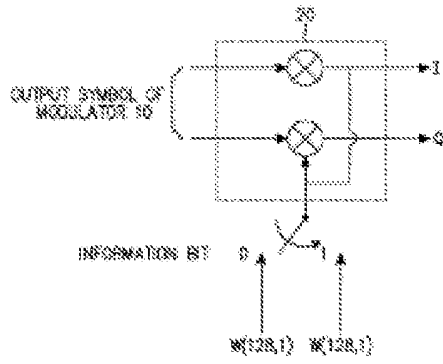


FIG. 6A

DETECTOR

DETECTOR

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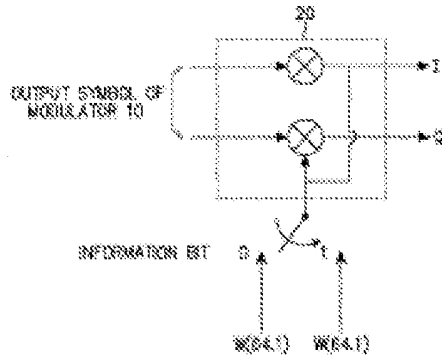


FIG. 6B

INTERNATIONAL SEARCH REPORT
Information reported by searching

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US 6125087 A	8 Sept. 2001	none	
US 6070885 A	8 May 2001	JP 2001561 A1	13 Apr. 2001
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US 6041187 A	8 May 2000	JP 2000001 A1	1 Feb. 2000
US 6034702 A	11 May 2000	JP 2000011 A1	27 May 2000

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(51)Int.Cl.

H04J 13/00

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(71)Applicant : SANYO ELECTRIC CO LTD

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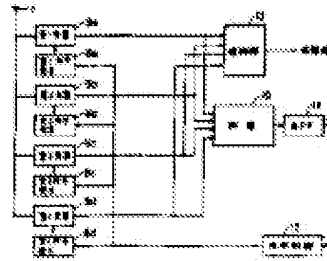
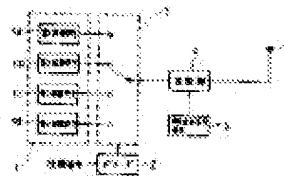
(72)Inventor : HIRAMATSU TATSUO

(54) SPREAD SPECTRUM COMMUNICATION SYSTEM

(57)Abstract:

PURPOSE: To improve S/N by constituting this system with a 1st equipment having a transmission means, a means receiving a spread spectrum signal, M-sets of code generating means, a means adding outputs of M inverse spread means and a 2nd equipment having a phase control means for a spread code.

CONSTITUTION: A decoder 2 outputs a signal selecting a spread code in response to transmission information, a spread code outputted from a selective circuit 3 is fed to a spread section 4 and a spread spectrum signal is sent via a transmission antenna 6. A reception side multiplies a spread spectrum signal received by a reception antenna 7 with codes from 1st - 4th code generating sections 8a - 8d to apply inverse spread processing to the spread spectrum signal.



⑤ Int. Cl.⁵

識別記号

庁内整理番号

⑬ 公開 平成4年(1992)2月6日

H 04 J 13/00

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7117-5K

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⑭ 発明の名称 スペクトラム拡散通信システム

⑮ 特 願 平2-138759

⑯ 出 願 平2(1990)5月28日

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 ⑲ 代 理 人 弁 理 士 西 野 卓 嗣 外2名

明 細 書

1. 発明の名称

スペクトラム拡散通信システム

2. 特許請求の範囲

(1) 異なるM個の拡散符号を発生する拡散符号発生手段、この拡散符号発生手段からのM個の拡散符号が供給され、情報信号に応じて1つの拡散符号を選択する選択手段、この選択手段にて選択された拡散符号と搬送波信号発生手段からの搬送波信号に関する信号とに基づき搬送波信号のスペクトラムを拡散するスペクトラム拡散手段、このスペクトラム拡散手段からのスペクトラム拡散信号を送信する送信手段を有する第1の装置と、

前記送信手段からのスペクトラム拡散信号を受信する受信手段、前記拡散符号発生手段から出力される各拡散符号と同一若しくは相関の大きいM個の符号を発生する符号発生手段、前記受信手段からの受信信号と前記符号発生手段からの各拡散符号とに基づき受信信号のスペクトラムを逆拡散するM個の逆拡散手段、このM個の逆拡散手段の

出力を加算する加算手段、この加算手段の出力端に接続されたフィルタ手段、このフィルタ手段の出力に基づき前記符号発生手段から出力される拡散符号の位相を制御する位相制御手段を有する第2の装置とよりなるスペクトラム拡散通信システム。

3. 発明の詳細な説明

(イ) 産業上の利用分野

本発明はスペクトラム拡散通信システムに関する。

(ロ) 従来の技術

従来、情報信号よりも充分広いスペクトラム幅を有する、例えば2進の疑似雑音符号(Pseudo Noise Code)(以下、PN符号と称す)でスペクトラムが拡散された搬送波信号を送信し、受信側では送信側で用いたのと同じのPN符号で受信信号を乗算することにより元の情報を復調する、所謂スペクトラム拡散通信が知られている(例えば、電子科学1978年11月号参照)。

また、近年では周波数利用効率の優れたものと

して、M-ary方式によるスペクトル拡散通信方式が提案されている（例えば、電子情報通信学会SSTA89-37；1989年11月8、9日参照）。

此種M-ary方式について簡単に説明すると、送信側に各々符号長及び発生速度が同一で且つ符号間で同期がとれている、異なるM個の拡散符号を発生する拡散符号発生器を設け、この拡散符号発生器からの拡散符号を情報信号に応じて選択し、この選択された拡散符号にて搬送波信号のスペクトラムを拡散して送信する。

一方、受信側では、前記拡散符号発生器からの各拡散符号と同じ若しくは相関の大きい、M個の符号を発生する符号発生器とを設け、受信信号と符号発生器からの符号とを各々乗算することにより、受信信号のスペクトラムを逆拡散する。

このとき、受信信号に含まれる拡散符号と同一若しくは相関の大きい符号が供給される乗算器の出力にのみ搬送波信号が再生されるので、この搬送波信号を検出することにより情報信号を復元す

この選択手段にて選択された拡散符号と搬送波信号発生手段からの搬送波信号とに基づき搬送波信号のスペクトラムを搬送するスペクトラム拡散手段、このスペクトラム拡散手段からのスペクトラム拡散信号を送信する送信手段を有する第1の装置と、前記送信手段からのスペクトラム拡散信号を受信する受信手段、前記拡散符号発生手段から出力される各拡散符号と同一若しくは相関の大きいM個の符号を発生する符号発生手段、前記受信手段からの受信信号と前記符号発生手段からの各拡散符号とに基づき受信信号のスペクトラムを逆拡散するM個の逆拡散手段、このM個の逆拡散手段の出力を加算する加算手段、この加算手段の出力端に接続されたフィルタ手段、このフィルタ手段の出力に基づき前記符号発生手段から出力される拡散符号の位相を制御する位相制御手段を有する第2の装置とよりなることを特徴とする。

(ホ) 作用

本発明に依れば、拡散符号発生手段からのM個の拡散符号の内、1つを情報信号に応じて選択し

ることができる。

(ハ) 発明が解決しようとする課題

ところで、スペクトラム拡散通信では、受信側で情報信号を正確に再生するためには、受信側で発生する符号を送信側の符号と同期させることが不可欠である。

上述したM-ary方式では、情報によって送信される符号系列が異なり、これを用いて同期確立を行なうことは難しいため、別途同期用の符号系列を同一帯域で同時に送るようにしている。

然し乍ら、この場合送信電力の一部を同期系列に割り与えるので、情報信号の拡散用系列のS/Nが少し下がり、復調時のデータ誤り率の増加を招いたり、同期用系列の電力が小さいと、同期捕捉に時間がかかるという問題を有していた。

(ニ) 課題を解決するための手段

上記の点に鑑み、本発明は異なるM個の拡散符号を発生する拡散符号発生手段、この拡散符号発生手段からのM個の拡散符号が供給され、情報信号に応じて1つの拡散符号を選択する選択手段、

てこの選択された拡散符号にて搬送波信号のスペクトラムを拡散して送信し、受信側では、前記拡散符号発生手段からの拡散符号と同一若しくは相関の大きい、M個の符号を発生させ、この符号と受信信号とに基づき受信信号のスペクトラムを逆拡散する。次いで、この逆拡散された信号を加算し、フィルタを通過させることにより位相制御情報を抽出してこの位相制御情報に基づき符号発生手段から出力される符号の位相を制御する。

(ヘ) 実施例

第1図は本発明システムに係る送信機の一実施例を示す図である。第1図において、(1)は異なるM個（図示の場合では、4個）の拡散符号を発生する拡散符号発生器で、第1拡散符号(PN1)を発生する第1拡散符号発生部(1a)と、第2拡散符号(PN2)を発生する第2拡散符号発生部(1b)と、第3拡散符号(PN3)を発生する第3拡散符号発生部(1c)と、第4拡散符号(PN4)を発生する第4拡散符号発生部(1d)とより構成されている。尚、各拡散符号

の符号長、発生速度は全く同じであり、また各符号間では同期が完全に与えられているものとする。(2)は情報信号に応じて選択信号を出力するデコーダ、(3)は第1～第4拡散符号発生部からの拡散符号の内、1つの拡散符号をデコーダ(2)からの選択信号に応じて選択する選択回路、(4)は選択回路(3)にて選択された拡散符号と搬送波信号発生回路(5)からの搬送波信号とに基づき搬送波信号のスペクトラムを拡散する拡散部で、乗算器より構成されている。(6)はスペクトラム拡散された信号を送信する送信アンテナである。

第2図は本発明システムに係る受信機の一実施例を示す図である。第2図において、(7)は受信アンテナ、(8a)は第1拡散符号発生部(1a)からの第1拡散符号(PN1)と同一若しくはは相関の大きい第1符号(PN1')を発生する第1符号発生部、(8b)は第2拡散符号発生部(1b)からの第2拡散符号(PN2)と同一若しくはは相関の大きい第2符号(PN2')を発生する第2符号発生部、(8c)は第3拡散発生部(1c)

タウ・ディザ回路や遅延ロックループ回路である。(13)は情報信号を復調する復調部である。

次に、動作について説明する。

今、伝達すべき情報が「00」、「01」、「10」、「11」の4つであったとすると、デコーダ(2)は前記情報に応じて拡散符号を選択する選択信号を出力する。即ち、情報「00」のとき、第1拡散符号(PN1)を選択する信号を、情報「01」のとき、第2拡散符号(PN2)を選択する信号を、情報「10」のとき、第3拡散符号(PN3)を選択する信号「11」のとき、第4拡散符号(PN4)を選択する信号を出力する。

情報が上述した順番に発生すると、選択回路(3)から出力される符号は、第3図に示す如く第1拡散符号(PN1)、第2拡散符号(PN2)、第3拡散符号(PN3)、第4拡散符号(PN4)の順になる。

斯様に選択回路(3)で選択された拡散符号は、拡散部(4)に供給され、拡散部(4)において搬送

からの第3拡散符号発生部(PN3)と同一若しくはは相関の大きい第3符号(PN3')を発生する第3符号発生部、(8d)は第4拡散符号発生部(1d)からの第4拡散符号(PN4)と同一若しくはは相関の大きい第4符号(PN4')を発生する第4符号発生部である。この第1～第4符号発生部にて符号発生器を構成しており、各符号は符号長、発生速度が同一で、然も同期しているものとする。(9a)は受信信号と第1符号(PN1')とを乗算する第1乗算器、(9b)は受信信号と第2符号(PN2')とを乗算する第2乗算器、(9c)は受信信号と第3符号(PN3')とを乗算する第3乗算器、(9d)は受信信号と第4符号(PN4')とを乗算する第4乗算器、(10)は第1～第4乗算器(9a)～(9d)の出力を加算する加算器、(11)は加算器(10)の出力端に接続され、搬送波信号成分を通過させるバンドパスフィルタ、(12)はバンドパスフィルタ(11)を通過した信号に基づき符号発生部から出力される符号の位相を制御する位相制御回路で、

波信号発生回路(5)からの搬送波信号と乗算される。その結果、搬送波信号のスペクトラムが拡散される。斯るスペクトラム拡散信号は、送信アンテナ(6)を介して送信される。

一方、受信側では、受信アンテナ(7)にて受信されたスペクトラム拡散信号と第1～第4符号発生部(8a)～(8d)からの符号とを各々乗算し、前記スペクトラム拡散信号を逆拡散する。

今、受信側符号と送信側符号とが同期し、且つスペクトラム拡散信号に含まれる符号系列が第4図(a)に示す如くなっていたとすると、このスペクトラム拡散信号と第1符号とを乗算する第1乗算器(9a)の出力端には、第4図(c)に示す如く、受信信号に含まれる第1拡散符号の期間だけ搬送波信号が再生される。尚、第2拡散符号～第4拡散符号の期間には、各拡散符号にてスペクトラム拡散されている信号が第1符号(PN1')にて更にスペクトラムが拡散されることになり、搬送波信号は再生されない。

以下、同様に第2乗算器(9b)の出力端に

は、第2拡散符号の期間だけ、第3乗算器(9c)の出力端には、第3拡散符号の期間だけ、第4乗算器(9d)の出力端には、第4拡散符号の期間だけ搬送波信号が再生される〔第4図(e)(g)(i)参照〕。

而して、加算器(10)の出力端には、搬送波信号が略連続して出力されることになり、これをBPF(11)を通過させることにより不要信号成分を除去した後、位相制御回路(12)に供給することにより符号発生器から発生される符号の位相を制御することが可能になる。

即ち、BPF(11)の出力は、従来の単一符号系列にてスペクトラム拡散した場合と同様に、送信側符号と受信側符号との位相関係に応じてレベルが変化するため、このレベル変化を利用して位相制御を達成することが出来る。

尚、受信側符号と送信側符号との同期点の検出は、従来と同様に受信側符号の位相を順次変化させることにより達成されるものとする。

上述の如く本発明の動作は達成されるが、本発

明は上記実施例に限定されるものではなく、変更された、搬送波信号をスペクトラム拡散する等種々変更が可能であり、また使用される符号系列も4つに限定されるものではない。

(ト) 発明の効果

本発明に依れば、拡散符号発生手段からのM個の拡散符号の内、1つを情報信号に応じて選択して、この選択された拡散符号にてスペクトラム拡散された信号を送信し、受信側では、M個の符号と受信信号とを各々乗算し、その乗算出力を加算して得られた信号に基づき位相制御を行なうようにしたので、格別に同期制御用の符号系列を送る必要がなく、情報信号の拡散用系列のS/Nの向上を計れる。同時に、システム全体の構成が簡単になり、コストの低減が計れる。

4. 図面の簡単な説明

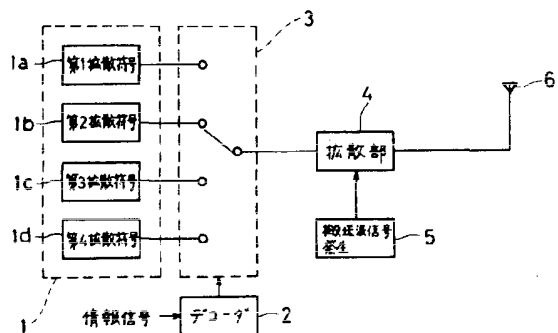
第1図は本発明システムの送信側を示す図、第2図は本発明システムの受信側を示す図、第3図(a)(b)は送信側の動作を説明するための図、第4図は受信側の動作を説明するための各部波形図

である。

(1)…拡散符号発生器、(2)…デコーダ、(3)…選択回路、(4)…拡散部、(5)…搬送波信号発生回路、(6)…送信アンテナ(送信手段)、(7)…受信アンテナ(受信手段)、(8a)(8b)(8c)(8d)…符号発生部、(9a)(9b)(9c)(9d)…乗算器、(10)…加算器、(11)…BPF、(12)…位相制御回路、(13)…復調部。

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代理人 弁理士 西野卓嗣(外2名)

第1図

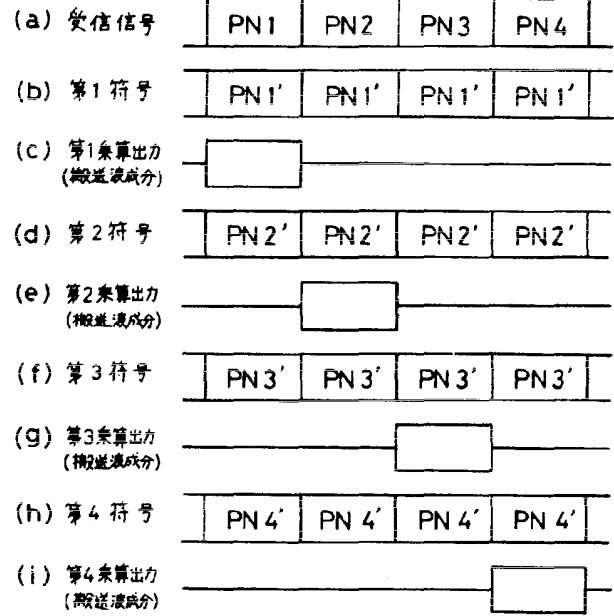
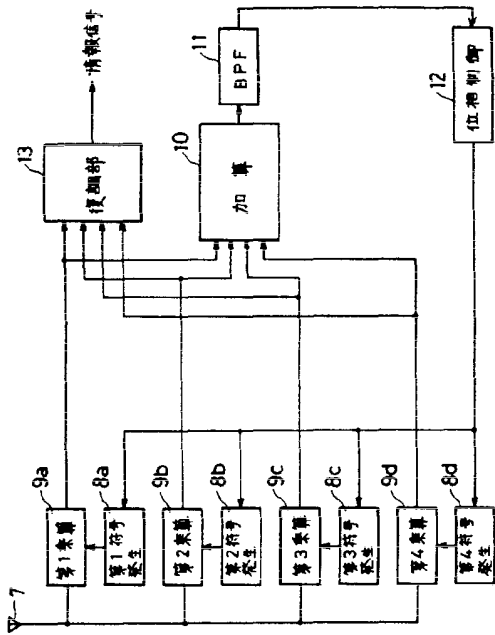


第3図

(a) 情報信号	00	01	10	11
(b) 拡散符号	PN1	PN2	PN3	PN4

第4図

第2図





Espacenet

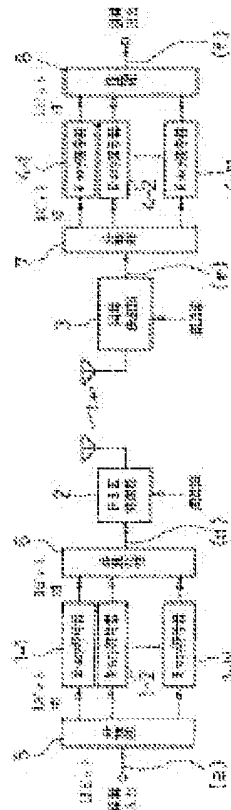
Bibliographic data: JP11154929 (A) — 1999-06-08

DIGITAL MODULATION DEMODULATION SYSTEM FOR RADIO COMMUNICATION

Inventor(s): YAMAOKA YASUSHI; ITOU SHIYOUO; OKUBO SHINZO; SHIMADA KOHARUTO; ADACHI FUMIYUKI ±
Applicant(s): NIPPON TELEGRAPH & TELEPHONE ±
Classification: - **international:** *H04J13/00; H04L27/00;* (IPC1-7): H04J13/00; H04L27/00
 - **European:**
Application number: JP19970319939 19971120
Priority number (s): JP19970319939 19971120

Abstract of JP11154929 (A)

PROBLEM TO BE SOLVED: To provide a digital modulation demodulation system for radio communication where error hardly takes place in fading while keeping a feature of the M-ary modulation demodulation system immune to interference. **SOLUTION:** A division section 5 divides transmission information into blocks each consisting of LN bits and further divides each block into N L-bits information series. Each M-ary coder 2 generates an M-ary orthogonal code for each L-bits information series. N-sets of orthogonal codes per block are multiplexed, each orthogonal code is spreaded into a length multiplied by N on a time base, and the carrier is digitally modulated by the multiplexed signal in order to be transmitted. A synchronization detector 3 at a receiver side detects a reception signal, a detection output is demultiplexed into N-sets of orthogonal codes, each M-ary decoder 4 determines correlation of each orthogonal code and discriminates an orthogonal code having the highest correlation, and the signal is demodulated. The L-bits information series corresponding to the orthogonal code are outputted, and the outputted N L-bits information series are restored to a signal in LN bits per reception unit.



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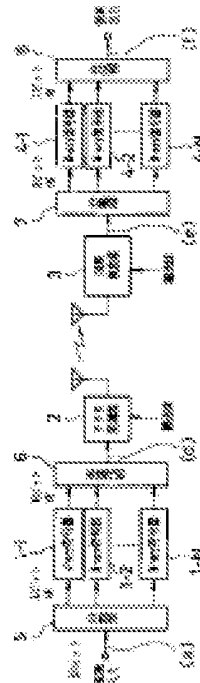
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 最終頁に続く

(54) 【発明の名称】 無線通信用デジタル変調方式

(57) 【要約】

【課題】 干渉に強いM-ary変調方式の特徴を保持しつつ、フェージングに対しても誤りの発生しにくい無線通信用デジタル変調方式を提供する。

【解決手段】 送信情報を分割部5でLNビットずつにブロック化し、各ブロックをN個のLビット情報系列に分割し、各M-ary符号器1で各Lビット情報系列に対してM-aryの直交符号を発生し、ブロック当りN個の直交符号を多重化して各直交符号を時間軸上でN倍の長さに拡散し、該多重化信号で搬送波をデジタル変調して送信し、受信側では球面検波器3で受信信号を検波し、検波出力をN個の直交符号に分割し、各M-ary復号器4は各直交符号の相互相関を求め、最も相関の高い直交符号を判定して信号を復調し、該直交符号に対応したLビット情報系列を出力し、この出力される受信単位当りN個のLビット情報系列をLNビットの信号に復元する。



【特許請求の範囲】

【請求項1】 送信側と受信側の間で無線通信を行う場合の無線通信用デジタル変復調方式であって、

送信側は、送信情報を予めL・Nビット（L、Nは2以上の自然数）ずつのブロックとし、それぞれのブロックをN個のLビット情報系列に分割する分割手段と、Lビット情報系列をLビットの符号として見た場合に各符号に対して一意に定めたMビット長の直交符号を発生する符号化手段と、該符号化手段から出力されるブロック当りN個の直交符号を多重化する多重化手段と、この多重化された信号で搬送波をデジタル変調する変調手段とを有し、

受信側は、送信側から受信した信号を検波する検波手段と、該検波手段からの検波出力を送信側での多重化に同期したNMビット時間長の受信単位とし、それぞれの受信単位をN個のMビット系列に分割する分離手段と、各Mビット系列に対して送信側で定めたすべての種類の直交符号との相互相関を求め、最も相関の高い直交符号を判定する相関検出手段と、該相関検出手段で判定された直交符号に対応したLビット情報系列を出力する復号手段と、該復号手段から出力される受信単位当りN個のLビット情報系列を送信側と逆の操作によりL・Nビットの信号に復元する合成手段とを有することを特徴とする無線通信用デジタル変復調方式、

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、移動通信等の端末と基地局間で無線通信を行う場合の無線通信用デジタル変復調方式に関し、特にフェージングによる受信信号強度の変動に強く、誤りの発生を軽減し得る無線通信用デジタル変復調方式に関する。

【0002】

【従来の技術】従来、移動通信など端末と基地局間で無線通信を行う場合のデジタル変復調方式としては様々な方式が知られているが、最近、注目されている方式に、直交符号によるM-ary変復調方式がある。M-ary変復調方式については、例えば、「横山光雄著”スペクトル拡散通信システム”第197ページ～213ページ、科学技術出版社発行1988年」に記載されている。

【0003】図9は従来のM-ary変復調方式のブロック構成例であり、1はM-ary符号器、2はPSK変調器、3は同期検波器、4はM-ary復号器である。変調入力端子に入力されたデジタル信号は、予めLビット（Lは2以上の自然数）ずつにブロック化され、このLビット情報系列をLビット符号として見た場合に各符号に対して一意に定めたM=2^Lビット長の直交符号をM-ary符号器1から発生する。例えば、図10に示した例（L=2）では、M=4となる。この場合、入力された情報2ビット（a1、a2）は同期の搬

送波により、4ビット長の直交符号C1～C4のいずれかに変換されて出力される。この直交符号でPSK変調器2は搬送波を2相位変調（BPSK）する。受信側では、同期検波器3で信号を検波し、M-ary復号器4は検波した信号に対して考えられる全ての直交符号C1～C4を掛け算して相互相関値を算出する。この結果、最も相関値の高い直交符号を受信信号と判定する。更にM-ary復号器4では判定された直交符号に対応する源情報2ビットを図10の変換規則により出力する。

【0004】なお、直交符号としては、通常の直交符号の他、陪直交符号も使用できることが知られており（例えば、「横山光雄著”スペクトル拡散通信システム”第203ページ～213ページ、科学技術出版社発行1988年」）、この場合M=2^{L+1}（L≧3）となる。

【0005】M-ary変復調方式では、異なる入力情報に対しては互いに異なる符号を用いるので、信号間の相互相関が0となる。これにより同一チャネル干渉が少ないという特徴を持つ。この特徴は、CDMA方式のように、同一周波数で複数の信号を多重化する場合の変復調方式として都合が良い。

【0006】しかしながら、移動通信環境では、フェージングによる受信電力の落ち込みが頻繁に発生し、熱雑音および急激な搬送波位相の回転によるバースト誤りが一般的に発生する。図11は、図10に示した例（L=2）におけるフェージング時の誤りの発生の様子を示す。図11において、フェージングによる受信電力の落ち込み時間T₁が複数ビットに渡る場合、フェージングの落ち込みに遭遇した直交符号（図11では斜線で示す）は熱雑音によって相関検出が困難となる。この結果、別の直交符号として誤って復号される可能性が高く、その場合、Lビット程度の長さのバースト誤りが発生する。

【0007】

【発明が解決しようとする課題】上述したように、従来のM-ary変復調方式では、フェージングによる受信電力の落ち込みによってバースト誤りが発生するという問題がある。

【0008】本発明は、上記に鑑みてなされたもので、その目的とするところは、干渉に強いM-ary変復調方式の特徴を保持しつつ、フェージングに対しても誤りの発生しにくい無線通信用デジタル変復調方式を提供することにある。

【0009】

【課題を解決するための手段】上記目的を達成するため、請求項1記載の本発明は、送信側と受信側の間で無線通信を行う場合の無線通信用デジタル変復調方式であって、送信側が、送信情報を予めL・Nビット（L、Nは2以上の自然数）ずつのブロックとし、それぞれのブロックをN個のLビット情報系列に分割する分割手段

と、Lビット情報系列をLビットの符号として見た場合に各符号に対して一意に定めたMビット長の直交符号を発生する符号化手段と、該符号化手段から出力されるブロック当りN個の直交符号を多重化する多重化手段と、この多重化された信号で搬送波をデジタル変調する変調手段とを有し、受信側が、送信側から受信した信号を搬送波を検波手段と、該検波手段からの検波出力を送信側での多重化に同期したNMビット時間長の受信単位とし、それぞれの受信単位をN個のMビット系列に分離する分離手段と、各Mビット系列に対して送信側で定めたすべての種類の直交符号との相互相関を求め、最も相関の高い直交符号を判定する相関検出手段と、該相関検出手段で判定された直交符号に対応したLビット情報系列を出力する復号手段と、該復号手段から出力される受信単位当りN個のLビット情報系列を送信側と逆の操作によりLNビットの信号に復元する合成手段とを有することを要旨とする。

【0010】請求項1記載の本発明にあっては、送信側で送信情報をLNビットずつにブロック化し、各ブロックをN個のLビット情報系列に分割し、符号化手段でそれぞれのLビット情報系列に対してM-aryの直交符号を発生し、この結果のブロック当りN個の直交符号を多重化して各直交符号を時間軸上でN倍の長さに拡散し、この多重化された信号で搬送波をデジタル変調して送信する。受信側では受信信号を検波し、検波出力を送信側での多重化に同期するよう受信単位でN個の直交符号（雑音を含む）に分離し、この分離された各直交符号と送信側で定めた全ての種類の直交符号との相互相関を求め、最も相関の高い直交符号を判定して信号を復調し、判定された直交符号に対応した元のLビット情報系列を出力し、この出力される受信単位当りN個のLビット情報系列を送信側と逆の操作によりLNビットの信号に復元する。

【0011】

【発明の実施の形態】以下、図面を用いて本発明の実施の形態について説明する。

【0012】図1は、本発明の第1の実施形態に係る無線通信用デジタル変調方式の構成を示すブロック図である。図1において、5は送信すべき情報LNビットをN個のLビット情報系列に分割する分割部、1-1~1-NはN系列のM-ary符号器、6はN個の直交符号を多重化する多重化部、2はPSK変調器、3は同期検波器、7は検波信号をN個のMビット系列に分離する分離部、4-1~4-NはN系列のM-ary復号器、8はN個のLビット情報系列を送信側と逆の操作によりLNビットの信号に復元する合成部である。

【0013】図1において、変調入力端子に入力されたデジタル信号は、分割部5においてLNビット(L、Nは2以上の自然数)ずつにブロック化され、各ブロックはさらにN個のLビット情報系列に分割されて出力さ

れ、それぞれがM-ary符号器1-1~1-Nへ入力される。次にM-ary符号器1-1~1-Nでは、入力に対してそれぞれ対応するM-aryの直交符号を従来の技術の場合と同様に発生する。例えば、L=2で通常の直交符号を使用した場合、M-ary符号器1-k(1≦k≦N)に入力された情報2ビット(s1、s2)は、図10の変換規則により、4ビット長の直交符号C1~C4のいずれかに変換されて出力される。また直交符号として、通常の直交符号の他、陪直交符号も使用でき、M=2^l(l≧3)となることは従来技術の説明で述べたとおりである。この結果得られたN個の直交符号を多重化部6が多重化する。多重化部6の出力はPSK変調器2に入力され、搬送波を位相変調する。

【0014】PSK変調器2の入力までの信号処理の詳細の例を図2に示す。図2はL=2、N=4、M=4の場合の例である。入力信号(a)は分割部5において、8ビットずつにブロック化され、この8ビットは2ビットずつの4系列に分割されてM-ary符号器1-1~1-4へ入力される。8ビットを4系列に分割する方法は任意であり、図では入力された順番に2ビットずつまとめて系列を作る例を示している。多重化部6では、4つのM-ary符号器から出力された信号をビット単位で多重化する。すなわち、M-ary符号器1-1から出力された4ビット長の直交符号は、図2の(d)の斜線でハッチングした4ヶ所(b11、b12、b13、b14)に配置され、M-ary符号器1-2から出力された4ビット長の直交符号は、それぞれ1ビットずつれた4ヶ所(b21、b22、b23、b24)に配置される。

【0015】受信側では、同期検波器3で信号を検波する。検波された信号は分離部7に入力され、送信側での多重化に同期したNMビット時間長の受信単位とされる。更に分離部7は、それぞれの受信単位をN個のMビット系列に分離して出力する。このN個の出力はそれぞれM-ary復号器4-1~4-Nへ入力される。次にM-ary復号器4-1~4-Nでは、入力された検波信号に対して考えられる全ての直交符号を掛け算して相互相関値を算出する。この結果、最も相関値の高い直交符号を受信信号と判定する。更にM-ary復号器では判定された直交符号に対応する源情報Lビットを送信側で用いた変換規則により出力する。合成部8は全てのM-ary復号器から出力されたN個のLビット情報系列を送信側と逆の操作によりLNビットの信号に復元する。

【0016】同期検波器3の出力以降の信号処理の詳細の例を図3に示す。図3は図2に対応する例である。4多重化された検波器出力(e)は、分離部7において、送信側の多重化部6と逆の操作により、4系列の信号に分離される。分離された4系列の信号はそれぞれM-ary復号器4-1~4-4へ入力される。M-ary復号

器4-1~4-4では、入力に対して最も相相値の高い直交符号を受信信号と判定し、判定された直交符号に対応する源情報2ビットを送信側で用いた変換規則(図10)により出力する。M-ary符号器4-1~4-4から出力された4系列の2ビット情報は合成部8で送信側と逆の操作により8ビットの信号に復元される。

【0017】次に、フェージングによる受信電力の落ち込みに対して、本実施形態では誤りが発生しにくいことを説明する。図2において斜線でハッチングした入力情報ビットa1(またはa2)に対応する直交符号4ビットは、変調器入力(d)ではb11~b14の位置に時間分散されて配置されている。このため、図3に示したフェージングによる受信電力の落ち込み時間T₁(T₁は図11と同一とする)内にはb14の1ビットのみが通過する。このため、相関検出時に異なる直交符号に誤って判定される確率が小さい。これに対して従来例の図11では、1つの直交符号の4ビットが連続して配置されていたために、フェージングによる受信電力の落ち込み時間内に複数ビット(図示では4ビット)が通過するので、誤判定の確率が大きい。

【0018】図1では、変復調方式としてPSK同期検波を示した。しかしながらフェージング環境では単に受信電力の落ち込みが発生するだけでなく、急激な搬送波位相の回転が起こるので、PSK同期検波では急激な搬送波位相の回転に追従できず、誤りが多く発生して良好な特性が得られない場合がある。このような場合には、PSK同期検波より、FSKエネルギー検波を用いた方が良好な特性が得られる。FSKエネルギー検波を用いる場合、図中のPSK変調器2の代わりにFSK変調器を用い、同期検波器3の代わりにFSKエネルギー検波器を用いれば、本発明の効果を得ることができる。

【0019】図4は、本発明の第2の実施形態の構成を示すブロック図である。第2の実施形態は、多値の変調方式を用いた場合のものである。図4において、5、1-1~1-Nは第1の実施形態と同様であり、9は多値変調に対応した多重化部、10は多値変調器、11は多値検波器、12は多値変調に対応した分離部、4-1~4-N、8は第1の実施形態と同様である。以下では、本実施形態の動作について、第1の実施形態と異なる多重化部9から分離部12までを主に説明する。

【0020】図4において、変調入力端子から多重化部9の入力までの各部の動作および信号の状態は図1の場合と同一である。多重化部9では、N個の直交符号を多重化して多値数に対応した個数の信号系列を出力する。多重化部9の出力は多値変調器10に入力され、搬送波を多値変調する。多値変調器10の入力までの信号処理の詳細の例を図5に示す。

【0021】図5は図2と同じL=2、N=4、M=4で、多値数が4値の場合の例である。入力信号(a)は分離部5において、8ビットずつにブロック化され、こ

の8ビットは2ビットずつの4系列に分離されてM-ary符号器1-1~1-4へ入力される。多重化部9では、4つのM-ary符号器から出力された信号をビット単位で多重化する。この例ではM-ary符号器1-1と1-3からの信号を多重化して(g1)なる系列を発生し、M-ary符号器1-2と1-4からの信号を多重化して(g2)なる系列を発生している。すなわち、M-ary符号器1-1から出力された4ビット長の直交符号は、図5の(g1)の斜線でハッチングした4ヶ所(b11、b12、b13、b14)に配置され、M-ary符号器1-2から出力された4ビット長の直交符号は、(g2)の4ヶ所(b21、b22、b23、b24)に配置される。(g1)と(g2)の同時刻の2ビットの情報を1シンボルとして、4値の変調を行うことができる。

【0022】多値変調の一例として、4値FSKエネルギー検波の場合の多値変調器および多値検波器の構成を図6に示す。図6において、13は4値FSK変調器、14は4値FSKエネルギー検波器である。4値FSK変調器13では、変調入力としてg1、g2があり、g1、g2の値に対して表に示す周波数を出力する。4値FSKエネルギー検波器14では、それぞれ中心周波数f₁、f₂、f₃、f₄を有する帯域通過フィルタBPF1~BPF4で受信信号をろ過した後、4つの検波出力を得、最も大きな検波出力が得られた周波数に対応する信号2ビットをh1、h2として出力する。

【0023】このようにして多値検波器11から出力された信号h₁は分離部12に入力される。多値検波器出力以降の信号処理の詳細の例を図7に示す。

【0024】図7は図4に対応する例である。4多重された検波器出力(h1)と(h2)は、分離部12において、送信側の多重化部9と逆の操作により、4系列の信号に分離される。分離された4系列の信号はそれぞれM-ary符号器4-1~4-4へ入力される。M-ary符号器4-1~4-4では、入力に対して最も相相値の高い直交符号を受信信号と判定し、判定された直交符号に対応する源情報2ビットを送信側で用いた変換規則(図10)により出力する。M-ary符号器4-1~4-4から出力された4系列の2ビット情報は合成部8で送信側と逆の操作により8ビットの信号に復元される。

【0025】次に、フェージングによる受信電力の落ち込みに対して、本実施形態での誤りの影響について説明する。図5において斜線でハッチングした入力情報ビットa1(またはa2)に対応する直交符号4ビットは、変調器入力(g1)ではb11~b14の位置に時間分散されて配置されている。このため、図7に示したフェージングによる受信電力の落ち込み時間T₁は、図3および図11と同一として

おり、図7のこの結果は、第1の実施形態で説明した結果と同じである。したがって、本実施形態においても、第1の実施形態と同様、相関検出時に異なる直交符号に誤って判定される確率が小さく、従来例に比べてフェージングによるバースト誤りの発生を軽減することが可能となる。

【0026】なお多値数としては、4値の他、8値、16値なども考えられ、変調器入力信号系列 (x_i) および検波器出力信号系列 (y_i) の数Hも、3系列 ($2^3 = 8$ 値)、4系列 ($2^4 = 16$ 値) と増えていく。このとき本発明による時間分散の効果を得るには、分割数Nを上記系列数H以上の数とすればよい。分割数Nが大きい程、時間分散の効果は大きく、フェージングによるバースト誤りの発生を著しく軽減することが可能となる。

【0027】多値の変調方式としては、多値FSKエネルギー検波のほか、多値PSK同期検波や16QAM (直交振幅変調) パイロット同期検波(三根線一著"地上移動通信用16QAMのフェージングひずみ補償方式"、電子情報通信学会論文誌(B-11)、vol. J72-B-11、No. 1を参照)など、様々な方式が使用可能である。

【0028】また、直交符号長Mが大きい程、時間分散の効果は大きく、フェージングによるバースト誤りの発生を軽減することが可能となる。

【0029】次に、図8を参照して、本発明の効果の一例を従来技術と比較して説明する。図8に示す例は、L=4、M=16、4FSK変調エネルギー検波を用い、最大ドップラー周波数4Hzの条件で200bpsの変調信号を送信した場合である。横軸は1ビットで復調化した受信S/N比 (E_b/N_0)、縦軸は平均ビット誤り率である。従来の場合に比べ、本発明(N=8および4)ではビット誤り率が大きく改善されることがわかる。また、Nが大きい程、平均化効果が大きいので、改善効果が大きいことがわかる。

【0030】上述した実施形態で参照した各構成図は本発明による動作原理を説明するための図であり、装置化にあたっては様々な実施形態が可能である。例えば、分割部、M-ary符号器、多重化部、分離部、M-ary復号器、合成部は、ハードウェア(論理回路)によって実現してもよいし、ソフトウェア(プログラム)による実現も可能である。

【0031】

【発明の効果】以上説明したように、本発明によれば、送信すべき直交符号を時間軸上でN倍の長さに拡散して

から送信し、受信側では時間分散された状態で直交符号(雑音を含む)を相関検出することにより、フェージングによる受信電力の落ち込みの影響を回避し、時間軸上で元の信号に復元するので、フェージングによるバースト誤りの発生を軽減することができ、これにより受信所要S/Nを低減できる。この結果、端末送信出力または上り信号の受信に必要な受信周数を低減でき、経済的なシステムを構築し得る。また、CDMA方式に用いた場合、容量を増大することができる。

【図面の簡単な説明】

【図1】本発明の第1の実施形態に係る無線通信用デジタル変復調方式の構成を示すブロック図である。

【図2】図1に示す実施形態における送信側の信号処理を示す説明図である。

【図3】図1に示す実施形態における受信側の信号処理とフェージング時の誤りの影響の様子を示す説明図である。

【図4】本発明の第2の実施形態に係る無線通信用デジタル変復調方式の構成を示すブロック図である。

【図5】図4に示す実施形態における送信側の信号処理を示す説明図である。

【図6】図4に示す実施形態に使用されている多値変調器および多値検波器の構成例を示す図である。

【図7】図4に示す実施形態における受信側の信号処理とフェージング時の誤りの影響の様子を示す説明図である。

【図8】本発明の効果例を示すグラフである。

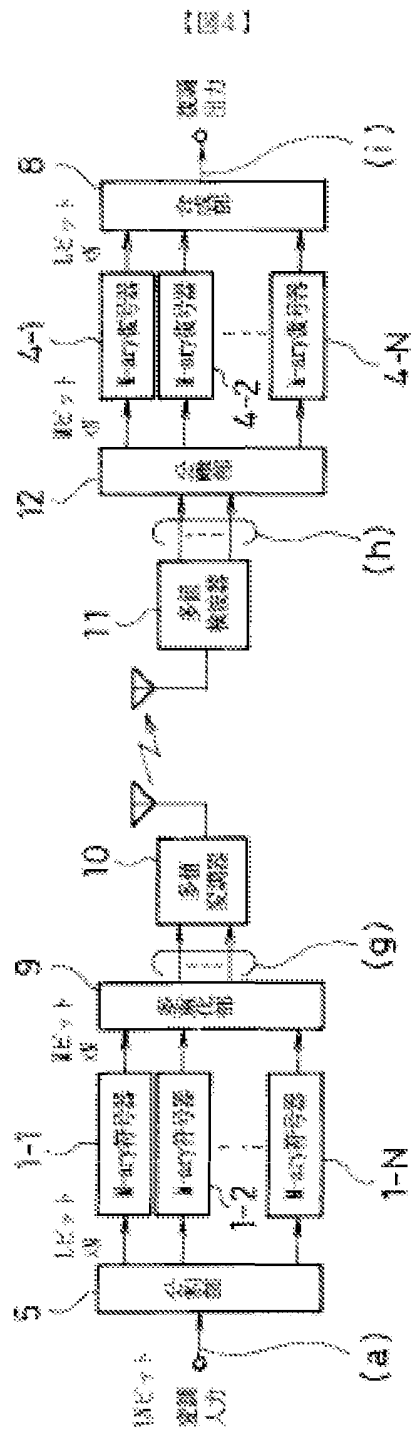
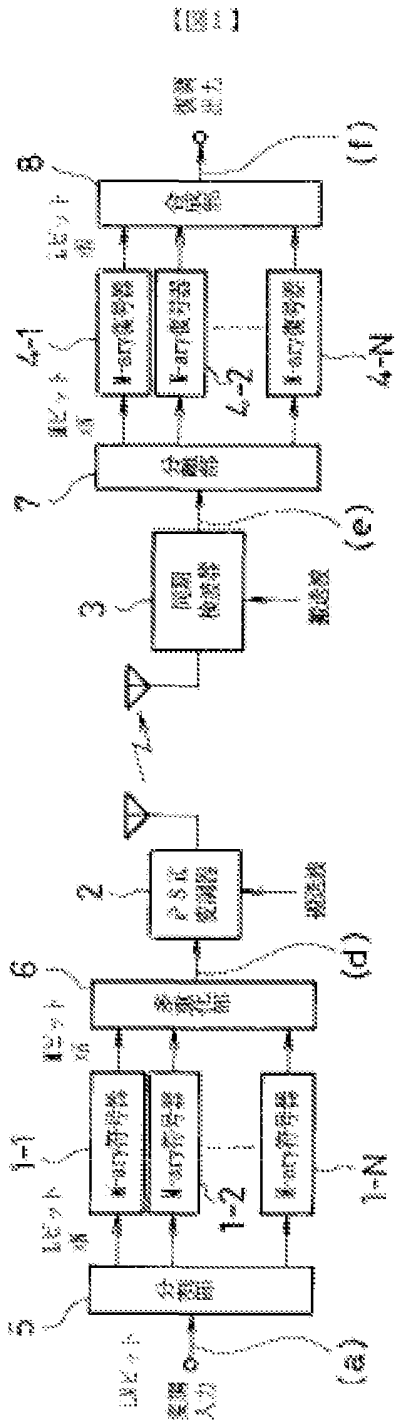
【図9】従来のM-ary変復調方式の構成を示すブロック図である。

【図10】M-ary符号器における変換規則を示す図である。

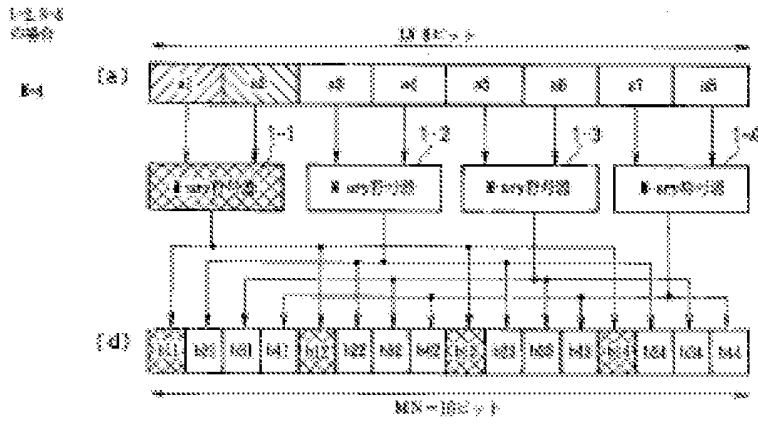
【図11】図9に示す従来例におけるフェージング時の誤りの影響の様子を示す説明図である。

【符号の説明】

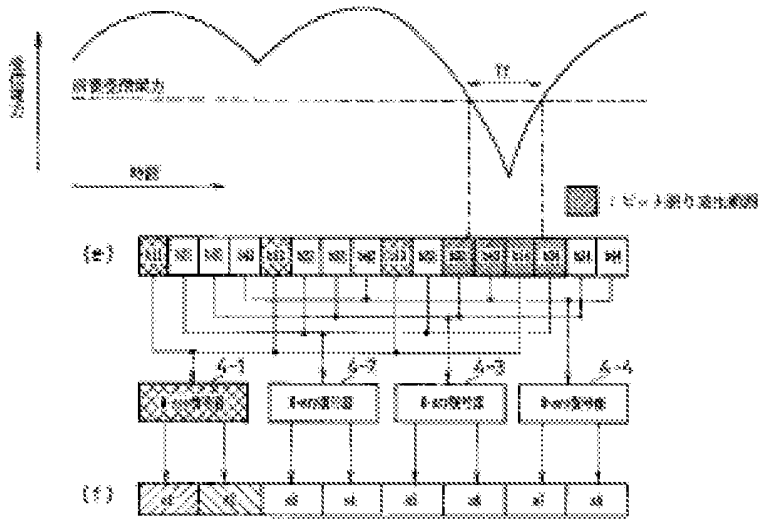
- 1-1~1-N M-ary符号器
- 2 PSK変調器
- 3 PSK同期検波器
- 4-1~4-N M-ary復号器
- 5 分割部
- 6、9 多重化部
- 7、12 分離部
- 8 合成部
- 10 多値変調器
- 11 多値検波器



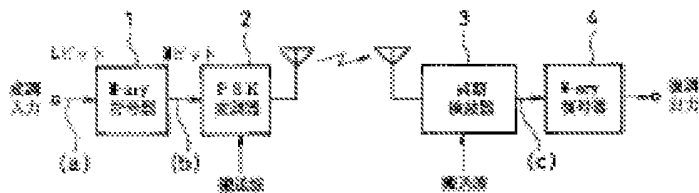
【図2】



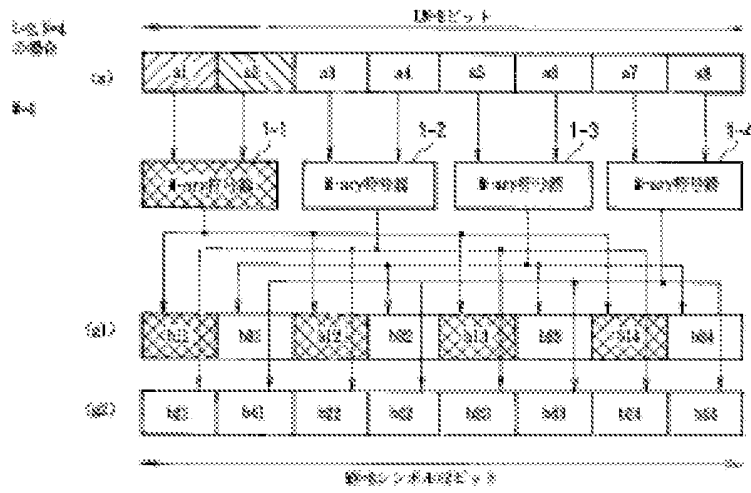
【図3】



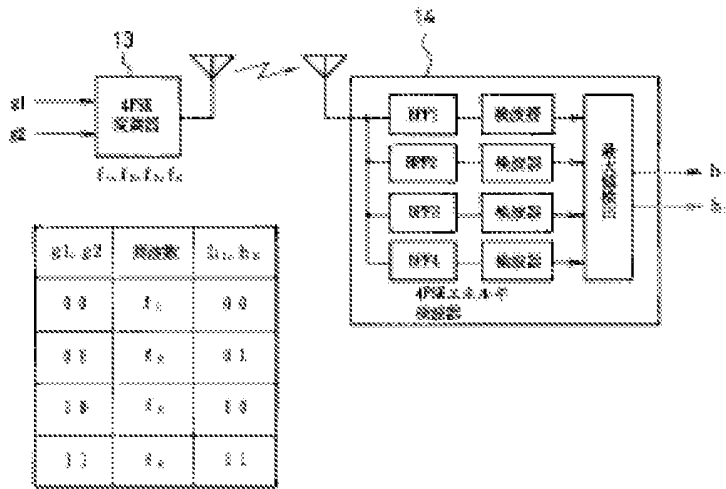
【図4】



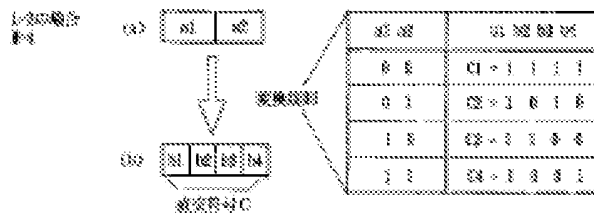
【図5】



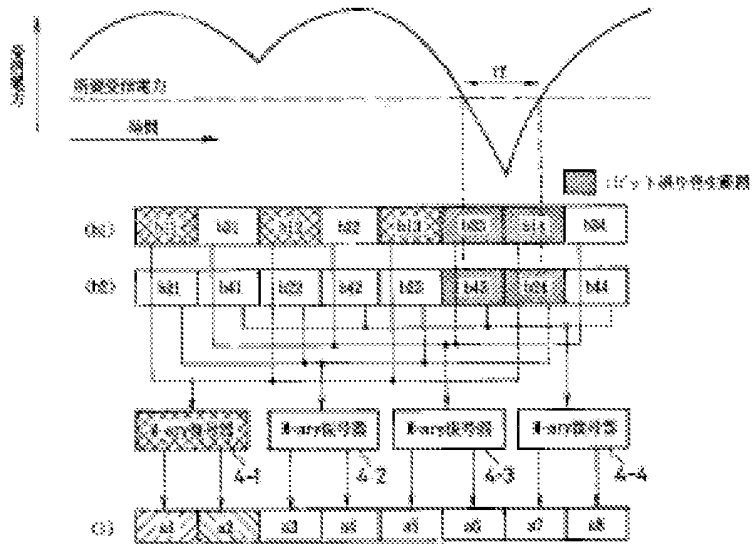
【図6】



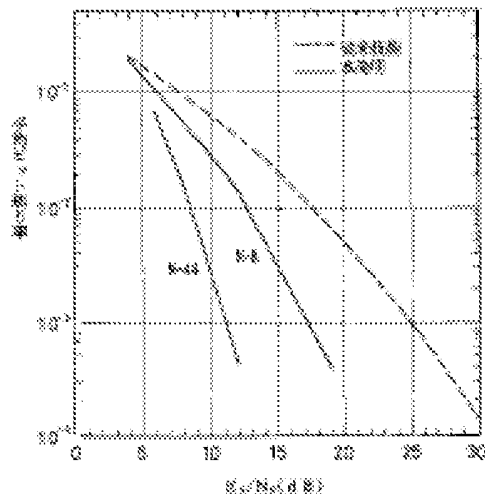
【図10】



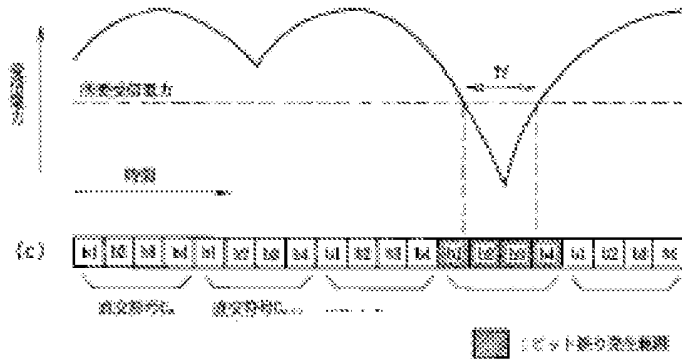
【図7】



【図8】



【図11】



フロントページの続き

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METHOD FOR GENERATING CODE RELATED TO PREAMBLE IN RANDOM ACCESS CHANNEL

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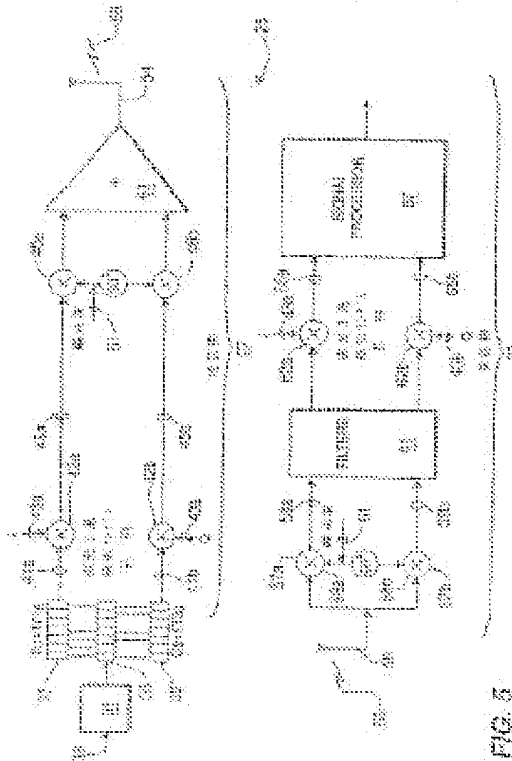
Application number: JP20040175917 20040614

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Abstract of JP2004274794 (A)

PROBLEM TO BE SOLVED: To provide a CDMA transmission and reception system that ensures high quality transmission and reception notwithstanding a communication distance and the Doppler effects. ; **SOLUTION:** A detector of the system detects a received digital signature using an energy output from a matched filter. The energies are tabulated according to an anticipated signature pattern for variable transmission distances. The tabulation accounts for expected round trip transmission delays and allows processing of the accumulated symbols to derive a correct signature independently of whether coherent or non-coherent signature coding is used and multiple Doppler channels are present. ; **COPYRIGHT:** (C) 2004,JPO&NCIP1



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果敢図に依り

(54) 【発明の名称】 ランダムアクセスチャネルのプリアンプに関連づけられた符号を発生する方法

(57) 【要約】

【課題】 受信遅延およびドップラー効果に影響されることなく高品質送受信を確保できるCDMA送受信システムを提供する。

【解決方法】 整合フィルタからのエネルギー出力を用いて受信デジタルシグネチャを抽出する検出器を提供する。変動し得る伝送遅延について予測されるシグネチャパターンにしたがってそれらエネルギー値を表にする。この表は往復伝達遅延の予想値を算入したものであり、遅延ずみのシンボルの処理は、採用シグネチャ符号化がコヒーレント型か非コヒーレント型かに関わりなく、また複数ドップラーチャネルの有無に関わりなく、正しいシグネチャの抽出を可能にする。

【図表】 図5

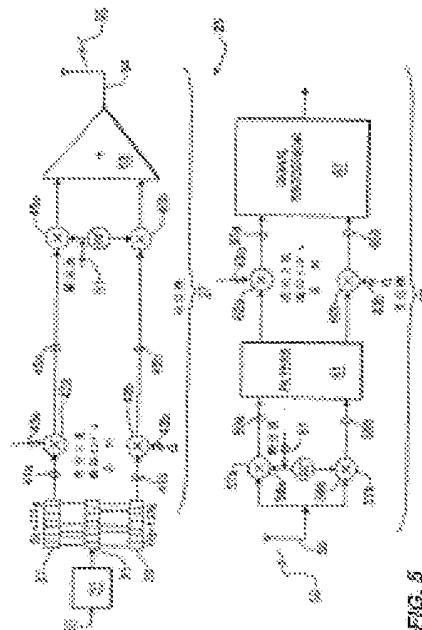


FIG. 5

【特許請求の範囲】

【請求項1】

ランダムアクセスチャネル（RACH）伝送信号のアリャンブルと関連づけた符号を生ずる方法であって、

各々が16個のシンボルを有する16個のアリャンブルシグネチャから一つのアリャンブルシグネチャを選択する過程と、

アリャンブルの符号系列に基づき符号を発生する過程と、

アリャンブル符号を生ずるように位相回転を行う過程と

を含む方法。

【請求項2】

前記発生する過程により発生した符号を、受信した符号系列との間で相関をとるのに用いる請求項1記載の方法。

【請求項3】

前記発生する過程により発生した符号を、受信したRACH伝送信号についてのドップラーを解消するのに用いる請求項1記載の方法。

【請求項4】

ランダムアクセスチャネル（RACH）伝送信号のアリャンブルと関連づけた符号を用いる加入者局ユニットであって、

各々が16個のシンボルを有する16個のアリャンブルシグネチャから一つのアリャンブルシグネチャを選択する手段と、

アリャンブルの符号系列に基づき符号を発生する手段と、

アリャンブル符号を生ずるように位相回転を行う手段と

を含む加入者局ユニット。

【請求項5】

前記発生する手段により発生した符号を、受信した符号系列との間で相関をとるのに用いる請求項4記載の加入者局ユニット。

【請求項6】

前記発生する手段により発生した符号を、受信したRACH伝送信号についてのドップラーを解消するのに用いる請求項4記載の加入者局ユニット。

【発明の詳細な説明】

【技術分野】

【0001】

この発明は概括的には2進符号変調を受けた信号の伝送システムおよび伝送方法に関する。より詳細にいうと、この発明は伝送距離の変動する移動通信環境で被変調信号を伝送する符号分割多元接続（CDMA）伝送システムに関する。

【背景技術】

【0002】

通信システムは送信元から送信先へ情報を伝送する一つの主要機能を有する。送信元の生ずる信号は時間とともに変動する電気信号で通常は構成される。

【0003】

送信元から送信先までの情報信号の伝送は、適量チャネルと呼ばれる適切な媒体を通じて行われる。チャネルの特性に整合するように情報信号を変化させる一つの方法を変調という。情報を帯びた信号の再生を復調という。復調プロセスは変調プロセスと論理的に逆のプロセスを用いて被変調信号を交換する。伝送チャネルが理想的な媒体であれば送信先における信号は送信元における信号と同じになるはずである。しかし、実際には伝送プロセスの間中に信号は多様な変形を受けそのために歪が生ずる。送信先における受信機は原信号以外の影響をすべて除去して原情報を再生しなければならない。

【0004】

現在の通信の大部分は、原アナログ信号をデジタル量に変換して伝送し、伝送されてきた情報の種類に応じてアナログ形式に再変換する手法によって行われる。最も単純なディジ

タル表示は任意のビット期間における情報が1または0の2進数値である表示である。その情報のとり得る値の範囲を拡大するために、3以上の値を表示するシンボルを用いる。3値シンボルおよび4値シンボルは三つの値および四つの値をそれぞれとり得る。変動する値は正負の整数で表示され、通常は対称的である。シンボルの考え方は、各シンボルのビット内容が特有のパルス形状を定めるので、情報のより大きい種相変を可能にする。シンボルのレベル数に応じて、それと同じ数の特有のパルス波形が存在する。送信元の情報をシンボルに変換し、そのシンボルで変調をかけてチャネル経由で伝送し送信先で復調する。

【0005】

通信システムの通常のプロセスが伝送情報に与える影響は計算でき割増である。しかし、送信元から送信先への伝送の期間中で計算不可能な要素は雑音である。デジタル伝送に雑音が増えると信号が劣化し伝送誤りの可能性が増大する。もう一つの伝送信号劣化は信号の同期関係に影響する地形、建造物および伝播距離に起因するマルチパス歪である。通信システムは情報信号の伝送する予測可能な変形を測定する必要があり、伝送中に実際に生じたそれら予測可能な変形を分析する手段を受信装置は受信時に備えている必要がある。

【0006】

単純な2進伝送システムは論理1に正極性のパルス、論理0に負極性パルスをそれぞれ用い、送信元から方形パルスを伝送する。送信先で受信するパルスは雑音やそれ以外の歪などを含む上記変形を受けたパルスである。

【0007】

誤りの発生を最少に抑えるために、受信装置で用いるフィルタの応答特性を送信元のパルス波形に整合させる。整合フィルタとして周知の受信装置フィルタは、伝送されてきたパルス波形が論理1か論理0かを容易に判定でき、デジタル通信に広く用いられている。整合フィルタは送信装置がシンボルに対応して生ずる特定のパルス波形にそれぞれ整合させてある整合フィルタをシンボル関係数でサンプルして、入力パルス波形とフィルタ応答特性とを相関させる出力を生ずる。入力がフィルタ応答特性と同じであれば、そのフィルタ出力はその信号パルスの全エネルギーを代表する大きい値を生ずる。その出力は通常入力に対して複素数で表示される量である。その整合フィルタの性能の最適値は正確な位相同期を要する受信信号パルスの正確なコピーに左右される。位相同期は位相同期ループ (PLL) の利用により容易に維持できる。しかし、パルス同期は整合フィルタにとって問題である。パルス列がシンボル時間に同期していなければシンボル間干渉 (ISI) が生ずる。

【0008】

従来技術による通信システムの例を図1に示す。このシステムは、符号分割多重化、より一般的には符号分割多元接続CDMAとして知られる手法を用いている。

【0009】

CDMAは、伝送すべきデータを擬似雑音信号で変調することによりデータを拡大帯域 (スペクトラム拡散した帯域) で伝送する通信技術である。伝送すべきデータの数千ヘルツに過ぎない帯域幅が数百万ヘルツに及ぶ周波数帯域に拡散されるのである。通信チャネルは互いに独立な m 個のサブチャネルに同時並行的に利用される。

【0010】

図示のとおり、ある帯域幅の一つのサブチャネルを、広帯域擬雑音 (p n) 系列発生器で発生した所定のパルス系列パターンを繰り返す特有の拡散符号と混合する。これら特有のユーザ用拡散符号は通常は互いに直交関係にあり拡散符号相互間の交叉相関をほぼ零にしている。データ信号を上記 $p n$ 系列で変調してデジタルスペクトラム拡散信号を生ずる。次に、そのデジタルスペクトラム拡散信号で搬送波信号を変調して順方向リンクを構成し送信する。受信装置は伝送されてきた信号を復調してデジタルスペクトラム拡散信号を抽出する。伝送されてきたデータを、合成した $p n$ 系列との相関を採って再生する。拡散符号が互いに直交関係にあれば、受信信号は特定の拡散符号と関連した特定のユー

ザ信号との間で相関をとることができ、その特定の拡散符号と関連した所望のユーザ信号だけを強めてそれ以外のユーザ向けのユーザ信号は強めない。これと同じ信号処理が逆方向リンクにも適用される。

【0011】

直相移変調 (FSK) などのコヒーレント変調手法を固定式または移動式の複数の加入者局ユニットに用いる場合は、加入者局ユニットとの同期を確保するために基地局からグローバルパイロット信号を継続的に送信する。加入者局は基地局と常に同期しそのパイロット信号の情報を用いてチャネル位相および強度パラメータを推算する。

【0012】

逆方向リンクについては、共通のパイロット信号は実現不可能である。逆方向リンクを形成するための基地局による初期捕捉のために、加入者局は所定のランダムアクセスチャネル (RACH) 経由でランダムアクセスパケットを送信する。このランダムアクセスパケットは二つの機能を備える。第1の機能は加入者局ユニットが送信中で基地局がその送信を高速度伝送受信内容を判定する必要がある初期捕捉のための機能である。RACHは基地局への逆方向リンクを立ち上げる。ランダムアクセスパケットの第2の機能は低データ速度の情報を専用の通話音声伝送チャネルを占有することなく伝送する機能である。クレジットカード情報など少量のデータを発呼データでなくランダムアクセスパケットのデータ部分に挿入する。基地局に送られると、その情報は送信中の他のユーザに転送できる。ランダムアクセスパケットデータ部分をアドレス用およびデータ用に用いることによって、利用可能な無線周波数信号の資源に負荷をかけることなくより高速のデータ通信に効率的利用ができる。

【0013】

ランダムアクセスパケットはプリアンプル部分とデータ部分とを含む。データ部分はプリアンプルと並列的に送ることもできる。従来技術ではランダムアクセスチャネルはプリアンプルおよびデータの両方に直交位相移変調 (QPSK) を通常用いている。

【0014】

基地局は受信したプリアンプルを調べて特有の拡散符号を検出する。RACHプリアンプルの各シンボルは一つの p - n 系列でスペクトラム拡散されている。整合フィルタを用いて基地局は相関を示す符号を継続的にサーチする。このデータ部分は所望のサービスについての命令を含む。基地局はデータ部分を復調し、音声、ファクスなど要求呼の種類を判定する。次に、基地局は逆方向リンクで加入者局ユニットが用いる特定の通信チャネルを割り当て、そのチャネルのための拡散符号を特定する。通信チャネルが割り当てられると、RACHは他の加入者局ユニット用に解放される。追加のRACHは複数の加入者局ユニットからの同時発呼により起こり得る衝突を除去してより高速の基地局検索を可能にする。

【0015】

逆方向リンクにおけるパルス同期をもたらす加入者局ユニットパイロット信号が吃ければ、伝送遅延アンビグエィティにより複合化したPSKなどのコヒーレント符号化手法を用いた場合に移動加入者局装置からのRACHの捕捉が困難になる。移動加入者局は基地局と同期しているので、RACHプリアンプルは所定の速度で伝送される。

【0016】

従来技術によるプリアンプルシグネチャの一つの例はシンボル16個で構成される。コヒーレントRACHプリアンプルシグネチャ16個の長を図2に示す。各シンボルは複素量であり拡散 p - n 系列256チップを含むパルス流形を備えるので、各シグネチャは4096チップを含む。RACHプリアンプルシグネチャ全体は1ミリ秒あたり4096チップ、すなわち1マイクロ秒あたり0.244チップのチップ速度で伝送される。

【0017】

各加入者局ユニットはグローバルパイロット信号からフレーム境界情報を受ける。基地局と加入者局との間の距離に応じて、フレーム境界情報は順方向リンク伝送遅延を受ける。逆方向伝送のRACHプリアンプルは同一の伝送遅延を受ける。伝送遅延のためにRACH

Cはアリアンブルの基地局への受信到達時間は

$$\Delta t = 2(\text{距離}) / C \quad (\text{式1})$$

で与えられる。ここで $C = 3.0 \times 10^8$ m/sである。

【0018】

この伝送遅延のために、加入者局ユニットについての距離アンビギュイティは距離に左右される。距離100mでは影響は無視できる。距離30kmでは遅延が4シンボルの伝送時間に近づく。表1は往復伝送遅延の影響を示す。

【0019】

【表1】

距離 (km)	往復伝送 時間 (msec)	チップ値	シンボル 間 隔
0	0	0	1
5	0.033	137	1
10	0.067	273	2
15	0.100	410	2
20	0.133	546	3
25	0.167	683	3
30	0.200	819	4

表1 距離アンビギュイティの影響

第1欄は移動局ユニットと一つの基地局との間の距離をkmで示す。第2欄はその基地局と加入者局との間の往復伝送遅延をミリ秒で示す。第3欄は基地局における整合フィルタのチップクロック位置を伝送フレーム境界の軸点を0として示す。この数値はフレーム境界の軸点を基準として加入者局ユニットからの最初のチップの受信時点を表す。第4欄は256個の受信チップの組上げのあとで生ずる最初の整合フィルタ出力の見込みの位置（基準はフレーム境界の軸点）を示す。加入者局ユニットの距離に応じて最初の四つのシンボルの任意の一つの期間中にシンボルが出力される。

【0020】

基地局は加入者局ユニットと同期しておらず搬送波基準も備えていないので、受信チップ系列のどこでRACHアリアンブルシンボルの軸点が始まるか基地局には不明である。整合フィルタは有効なシンボルパルス波型対応の合計256チップの相関をとらなければならぬ。当業者には周知のとおり、チップを受信しながら整合フィルタの256個のチップを組み立ててパルス波型対応の最初の出力を生ずる。整合フィルタからの継続出力を後続の受信チップの各々について発生する。

【0021】

移動加入者局ユニットは基地局からのRACHにアクセスするためにアリアンブル部分を初めに送信する。シグネチャ16個のうち1個をランダムに選び時間的にずれた5個のうち1個をランダムに選んで伝送中の距離アンビギュイティを解消する。移動加入者局ユニットは基地局からのフレーム境界情報の一斉通知を絶えず受信する。RACHを要求するには、移動加入者ユニットは図3に示すとおり受信フレーム境界情報から $n \times 2m$ ($n = 0, 1, \dots, 4$) 時間的にずれたランダムバーストを送信する。この時間オフセット (n の値) をランダムアクセス試行の度ごとにランダムに選ぶ。

【0022】

基地局が受信した四つの受信アリアンブルシグネチャa, b, cおよびdを図4a乃至

図4dに示す。各シンボルレグネチャは往復伝送遅延のために1シンボル幅(0.0625ms)遅れて到着し、各レグネチャが基地局と移動加入者局ユニットとの間の互いに異なる距離を表す。距離アンビギュエティがレグネチャ相互間の遅延性を異なる程度を劣化させることが知られている。基地局受信機が整合フィルタから生じ得る19個の電力の任意の組合せを選ったレグネチャと選択する可能性がある。

【0023】

【特許文献1】EP 0 378 417

【非特許文献1】IEEE Transactions on Communications, Vol. 34, No. 3 pp. 219-226 (1986年3月)

【特許文献2】USP 5 696 762

【特許文献3】WO 98 49859

【発明の簡示】

【発明が解決しようとする課題】

【0024】

したがって、伝送距離の大きさおよびドップラー効果に関わりなく正確に動作するCDMA送信および検出方式が必要になっている。

【課題を解決するための手段】

【0025】

この発明は、整合フィルタからのエネルギー出力を正常な相関検出との連携で用いることにより、伝送されてきたデジタルレグネチャを検出する検出器に関する。変動する伝送距離について見込まれるレグネチャパターンにしたがってエネルギーを喪失する。この発明は往復伝送遅延品質を説明し、累計シンボルの処理が、利用符号化動作のコヒーレント型非コヒーレント型の区別に関わりなく、また複数ドップラーチャネルの有無に関わりなく、正しいレグネチャを検出できるようにする。この発明の上記以外の実施例には、RACHアリアンプルレグネチャを差動符号化する新たな手法が含まれる。

【発明の効果】

【0026】

送信距離およびドップラー効果に影響されることなく高品質受信を確保できるCDMA送受信システムを提供できる。

【発明を実施するための最良の形態】

【0027】

同じ構成要素には同じ参照数字を付けて示した図面を参照して好ましい実施例を次に説明する。

【0028】

図5に示したCDMA通信システム25は送信機27と受信機29とを含み、これら送信機25および受信機29は基地局にも移動加入者局ユニットにも配置できる。送信機27は音声信号および非音声信号を多様な速度、例えば8kbps、16kbps、32kbps、64kbpsなど所望の速度で符号化するシグナルプロセッサ31を含む。シグナルプロセッサ31は信号の種類に応じ、または所定のデータ速度に応じて速度を選択する。

【0029】

背景を述べると、多元接続環境においては、送信信号の発生に二つのステップが伴う。第1に、2相位相変調を受けた被変調信号と考えることができる入力データ33を前向き誤り訂正(FEC)符号化装置35により符号化する。例えば、 $R=1/2$ 畳込み符号を用いた場合は、単一の2相位相変調データ信号が二つの2相位相変調信号になる。一つの信号は同相チャンネルI 41aを表す。もう一つの信号は直交位相チャンネルQ 41bで示す。複素数は $a+jb$ の形になる。ここで、 a と b とは実数であり、 $j^2=-1$ である。2相位相変調信号IおよびQは通常QPSKと呼ぶ。

【0030】

第2のステップでは、二つの2相位相変調データすなわちシンボル41a、41bを誤率削減雑音(pn)系列43a、43bでスペクトラム拡散する。QPSKシンボルストリーム41a、41bを特有の雑音pn系列43a、43bと乗算する。I系列および

Q系列43a、43bの両方ともシンボル速度の通常100倍乃至200倍の速度で発生したビットストリームから成る。複素pn系列43a、43bをミキサ43a、43bで複素シンボルビットストリーム41a、41bと混合してデジタルスペクトラム拡散信号45a、45bを生ずる。このスペクトラム拡散信号45a、45bの構成部分はパルス幅のずっと小さいチップとして知られる。これらデジタルスペクトラムIおよびQ信号45a、45bをミキサ46a、46bにより無線周波数にアップコンバートとして、コンバイナ53で拡散符号の異なる他のスペクトラム拡散信号(チャネル)と合成し、搬送波51と混合してその信号をRFにアップグレードし、アンテナ54から一斉雑知信号55として放射される。この送信信号55には互いに異なるデータ速度の複数のチャネルが含まれる。

【0031】

受信機29は、アンテナ56で受けた広帯域送信信号55の受信出力を中間周波数搬送波59a、59bにダウンコンバートするミキサ57a、57bを含む。ミキサ59a、59bにおける第2段ダウンコンバート動作でこの信号をベースバンド信号に変換する。次に、QPSK信号をフィルタ61によりフィルタ処理して、送信機複素符号の共役値と一致するミキサ62a、62bでローカルに発生した複素pn系列43a、43bと混合する。送信機27における拡散符号と同じ符号で拡散された原波形だけが実効的に逆拡散される。それ以外の受信信号波形は受信機29には雑音として認識される。次に、データ65a、65bをシグナルプロセッサ67に送り、畳込み符号化済みデータをFEC復号化する。

【0032】

信号を受信し復号化したあとでは、ベースバンド信号はチップレベルにある。信号のI成分およびQ成分の両方をスペクトラム拡散動作で用いたpn系列の共役値を用いて逆拡散し、信号をシンボルレベルに戻す。

【0033】

移動加入者局ユニットから基地局への送方向リンクを確立するために移動加入者局ユニットはRACHで伝送されるランダムアクセスパケットを送信する。RACHの送信は、RACHがFECを受けない以外は上述の場合と同じである。通信システム25において二つ以上のRACHを用いる場合もある。

【0034】

上記16個のコヒーレントPSK変調済みRACH71アリアンブルシグネチャ73の表を図2に示す。各シグネチャは16個のシンボルを含む。各シンボルAは複素数 $A = 1 + j$ である。符号化の手法および複素数の説明はこの明細書の対象外であり当業者に周知である。

【0035】

従来技術によるコヒーレントRACH71検出器75を図6Aに示す。受信機29がRACH71搬送波を復調したのち、復調出力信号77がRACHアリアンブル73の逆拡散のために整合フィルタ79に入力される。整合フィルタ79の出力をアリアンブル相関器81に加えて、RACHアリアンブル73とアリアンブル符号83表の列相関アリアンブルpn系列との間の相関をとる。アリアンブル相関器81の出力は、上記特定のアリアンブル符号83による受信ランダムアクセスパケットのタイミング87に対応するピーク値85を有する。次に、この検出されたタイミング87は通常のRAKE89コンバイナでRACH71パケットのデータ部分の受信機に用いることができる。この検出器75は図2に示したコヒーレントPSK符号化アリアンブルシグネチャで理想的な条件下では十分に動作するが、距離アンビグエィティおよびドップラー効果によって動作が劣化することもあり得る。

【0036】

この発明の第1の実施例では、非コヒーレント検出を利用可能である。その実施例では、図2に示したコヒーレントRACHアリアンブルシグネチャ73は変調符号化される(すなわち、差動位相変調(DPSK)処理される)。したがって、上記コヒーレント

プリアンブルシグネチャ73は送信前にまず非コヒーレントDPSK符号化信号に変換され、受信後に差動復号化される。

【0037】

コヒーレントシグネチャの非コヒーレントシグネチャへの変換の方法は次のステップを経て実施される(ここで、i一行、j一列である)。すなわち、まず

$$S_{i,j}(1,1) = -A \text{ の場合: } i \text{ 対応の全 } j \text{ に } -1 \text{ を乗算。 (式2)}$$

例えば、図2に示したシグネチャ4(i=4)については、

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	-A	A	-A	A	-A	-A	-A	-A	-A	A	-A	A	-A	A	A	A

に-1を乗算して、

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	A	-A	A	-A	A	A	A	A	A	-A	A	-A	A	-A	-A	-A

が得られる。この第1のステップのあとでは、プリアンブルシグネチャは元の非変換シグネチャ(1, 3, 5, 8, 9, 11, 12および13)と-1乗算済みのシグネチャ(2, 4, 6, 7, 10, 14, 15および16)とから成る。

【0038】

この変換処理の第2ステップはプリアンブルシグネチャ73の各連続シンボルを交換する。この処理は次式、すなわち

$$S_{i,j}(1, j) = S_{i,j-1}(1, j-1) \text{ の場合: } S_{i,j}(1, j) = A \text{ (式3)}$$

$$S_{i,j}(1, j) = S_{i,j-1}(1, j-1) \text{ の場合: } S_{i,j}(1, j) = -A \text{ (式4)}$$

で表される。この例をさらに続けると、シグネチャ4(i=4)については

$$S_{i,j}(4, 2) = S_{i,j-1}(4, 2-1), -A = A$$

したがって、

$$S_{i,j}(4, 2) = -A$$

となる。

【0039】

DPSK符号化処理のこのあとの部分を、与えられたプリアンブルシグネチャ73の各連続シンボルについて行う。この処理により、16個のプリアンブルシグネチャ73のすべてを、図10に示した差動プリアンブルシグネチャ97に変換する。このDPSK変換は予め計算して移動加入者ユニットの一部としてファームウェアにロードすることができ、また基地局受信機の性能の程度に応じて発呼時に計算することもできる。DPSKプリアンブルシグネチャについては、プリアンブルシグネチャとの相関の前に受信信号を差動復号化により再生する必要がある点を除き、上述の処理と同じ処理を行う。

【0040】

この発明により構成したRACH検出器101を図5Bに示す。従来技術による受信機75について上に述べたとおり、受信RACH77は復調して帯域フィルタ79の入力に加える。帯域フィルタ79の出力をRAKES9、遅延手段103および第1のミキサ105に加える。受信シグネチャ97の各々は1シンボル毎、すなわち256チップ分だけ遅延させる。遅延手段103の出力を共役演算器107に加えて受信シンボルをその共役線に変換する。複素共役演算器107の出力を第1のミキサ105に加えて、このミキサ105により複素乗算の実部を選択106し、シグネチャと出力系列との間の相関をとる。この和をピーク検出器85で検出し、16番目のシンボルの検出までにその和が閾値を超えた場合にシグネチャ検出と判定する。各シグネチャにつき1回の計算で合

計16回の計算を伴うので、あるサンプル期間に累算値が2回以上閾値を超える場合もあり得る。その場合は最大の累算値を正しい累算結果として選択する。タイミング推測器87の推算出力をRACH71のバーストのデータ部分の受信のための通常のRAKE89コンバイナで用いることができる。

【0041】

この発明の第2の実施例によると、RACH検出器整合フィルタ79の各出力からの出力エネルギーを算出する。整合フィルタ79は通常チップ速度でサンプリングするが、チップ速度の2倍または4倍（またはそれ以上）の速度でオーバーサンプリングすることもできる。この実施例ではチップ速度は毎秒4、096メガチップ、すなわち0、244マイクロ秒あたり1チップである。

【0042】

整合フィルタ79からの各シンボル出力について算出したエネルギー値を蓄積したRAM100内のメモリマトリクス101を図7Aに示す。マトリクス101は、100mから30kmの距離の基地局・加入者局間伝送距離に対応の遅延シンボル値のあり得る値すべてを蓄積するように構成してある。マトリクス101はRACHプリアンブルシグネチャ期間中に送信されるチップの総数を表す256行（0乃至255）102、19列（0乃至18）104から成る。加入者局ユニットが基地局近傍の位置にあって伝送遅延が無視できる場合は、256チップ受信後、すなわち点P（255、0）で第1のシンボルが出力される。加入者局ユニットが距離30kmに位置する場合は、第1のシンボルは819シンボル受信後、すなわち点P（54、4）で出力される。伝送距離に関わりなく、256チップ分の時間の経過の度ごとに次のシンボルが出力され、それを繰り返して一つの行を完結させる。シンボル16個で一つのプリアンブルシグネチャを構成しているので、マトリクス101は距離アンビギュイティを予測して追加のシンボル出力3個を収容できる（図4に示す、詳細についてさらに後述）。マトリクス101がデータ収容すると、距離30kmまで移動加入者局ユニットの対象サンプル全部を含む。

【0043】

整合フィルタ79からの各出力97は複素数、すなわち

$$z(l, k) = x(l, k) + jy(l, k),$$

ただし $l=0$ から 255, $k=0$ から 18 (式5)

で与えられる。各出力の実部および虚部の2乗の和で表されるエネルギー瞬時値は次式、すなわち

$$p(l, k) = z(l, k)z(l, k)^* = x^2 + y^2$$

(式6)

で与えられ、マトリクス101に蓄積される。

【0044】

プリアンブルシグネチャは各々が特定のチップパターンを有する16個のシンボルひと組から成るので、整合フィルタ出力には平均値よりも大きい出力であって先行のものから各々が256チップ分の間隔を保った出力が16個現れる。合成出力はこれら整合フィルタ出力の256チップごとの和である。ここで解決すべき問題は、最初の整合フィルタ出力が最初の256チップ期間中には自動的に生じないことである。表1に示すとおり、移動加入者局ユニットと基地局との間の距離に応じて遅れて生ずることがあり得る。

【0045】

プリアンブルシグネチャがある場合は、それに対応する整合フィルタ出力は256行（102）のうちの一つの19個の要素のうち16個に格納される。各行について、その行のエネルギー加算値が既定の閾値を超えるとプリアンブルシグネチャ全部が検出される。

【0046】

図7Bを参照すると、プリアンブルシグネチャの検出手順200が示してある。マトリクス101にデータ格納すると（ステップ201）、各行についてエネルギー値を加算109し、同様に蓄積する（ステップ202）、加算出力の和の値が閾値を超えた行に

ついで、その行で「假検出」があったと考える。第1行についての和の値を所定の閾値を超えているか否かを判定する(206)。超えている場合は、その行に假検出と印を付ける(ステップ208)。各行についての加算が行われなかった場合は(ステップ210)、次の行を検索して(ステップ212)上記プロセスを反復する(ステップ206-210)。これら行のすべてについて加算を行うと、假検出の各々について距離アンビグエィティは解消し(ステップ214)、(さらに詳しく後述)、候補の値が出力される(ステップ216)。

【0047】

上述のとおり移動加入差局ユニットの位置によっては距離アンビグエィティが生じ、プリアンプルシグネチャが最大4シンボル分の距離に当たり生じない場合があり得る。この距離アンビグエィティを解消する必要がある。したがって、假検出と印を付けた行の各々について、その行の中で加算出力最大値を生ずる16個の互いに連続した位置のエネルギーの値を算定しなければならない。距離アンビグエィティのために、プリアンプルシグネチャの受信出力から四つのケース1、3、3および4を導き出さなければならない。これら四つのケースを図8に示す。この図では、シグネチャ1は送信されて19個の受信シンボルからアセンブルされて、メモリマトリクス101の一つの列を形成する。これらケースの各々について、19個のシンボルのうちの互いに連続した16個のシンボルを16個のあり得るプリアンプルシグネチャの各々と相関をとり、64個の假説出力を生ずる。これら64個の假説出力のうちの一つが受信エネルギー最大のシグネチャとなる。これら64個の假説出力の最大値はケース1で生ずる。ケース1は互いに連続したシンボル全部を含んでおり、雑音を含んでいないからである。ケース2、3および4は雑音成分から導かれたシンボルを含んでおり、16個のプリアンプルシグネチャの一つと相関しない。

【0048】

図7Cを参照すると、この図明による距離アンビグエィティ解消の手順300が示してある。図8を参照して述べたとおり、各行は合計19の位置を備える。図7Cにおいて、假検出とみられた一つの行の初めから16個の互いに連続した位置のエネルギーの値を分析する(ステップ301)。これら16個の位置のエネルギー総和を算出し(ステップ302)、蓄積する(ステップ304)。その行のすべての位置の合計値が算出されなかった場合は(ステップ306)、要素2乃至17に対応する次の16個の互いに連続する位置を見直す(ステップ308)。次に、カウンタを歩進させて(ステップ310)、上記手順を反復する(ステップ302乃至306)。すべての位置についての合計を算出すると、合計値すべてを比較してその行の互いに連続した16の位置に最大合計値を示す位置があるか否かを判定する。次に、このシステムは最大合計値を示す16個の連続位置の初めに対応する列(k)の値を出力する(ステップ314)。これが被選択候補である。上述の手順を假検出の各々について反復する。

【0049】

図7を参照して述べたプロセスは擬似符号を用いて次のとおり要約できる。

【0050】

行i (i = 0乃至255)
 和(k) = 0, k = 0, 1, 2, 3
 k = 0乃至3につき次式を計算。すなわち
 和(k) = 和(k) + P(1, n + k - 1)
 次のk。

次に、

最大の和(k)についてkを選択する
 $max_k = 0$
 $max = 和(0)$
 k = 1乃至3について
 和(k) > maxの場合
 $max = 和(k)$

max k = k
次のk、

上述の最適検出手順をコヒーレントまたは非コヒーレントPSK符号化のための通常の相関検出プロセスの形と比較する。通常の相関検出プロセスはこの明細書による説明の範囲外であり、当業者には周知である。

【0051】

図9を参照すると、直交性と距離アンビグイティとの関係の表が示してある。第1列は受信信号が相関を示すシグネチャである。第2列乃至第5列はケース1乃至4の相関値である。相関値が大きいほど受信信号との一致度が高い。相関値等は受信シンボルがそれぞれのシグネチャシンボルと直交関係にあることを示す。明らかに理解されるところ、ケース2、3および4についてはそれぞれのシグネチャ相互間には直交性がない。

【0052】

図9に示した相関値は次式、すなわち

【式7】

【0053】

$$\frac{100}{1024} \left| \sum_{i=0}^{15} P_i^{(1)} \cdot P_{i+l}^{*(k)} \right|^2 = \frac{100}{1024} \left| \sum_{i=0}^{15} P_i^{(1)} \cdot P_{i+l}^{*(k)} \right|^2, k = 1, 2, \dots, 16; \text{ Equation 7}$$

で与えられる。ここで、シグネチャ1についてk=1、シグネチャ2についてk=2、・・・、シグネチャ16についてk=16；ケース1についてl=0、ケース2についてl=1、ケース3についてl=2、ケース4についてl=3。値1024は次式、すなわち

【式8】

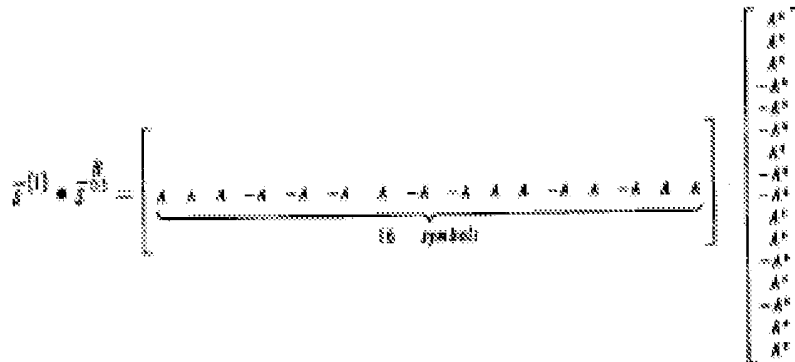
【0054】

$$1024 = \left| \sum_{i=0}^{15} s^{(1)} \cdot s^{(k)} \right|^2, \text{ ここで } s^{(1)} = \text{シグネチャ1} \quad (\text{式8})$$

で誘導される。また、次式

【式9】

【0055】



Equation 9

$$\begin{aligned}
 &= 16 \times A * A' \\
 &= 16 \times |H| |1-j| \\
 &= 16 \times 2 \\
 &= 32 \quad \text{および}
 \end{aligned}$$

$A = 1+j$ の場合、

$A * = A(1-j)$ の共役値、

したがって $32^2 = 1024$ が得られる。

【0056】

この発明の実施例により構成したRACH抽出器95を図11に示す。図6Aの従来技術による受信機について上に述べたとおり、受信したRACH77を識別して整合フィルタ79の入力に供給する。整合フィルタ79の出力をRAKE89、時間遅延ユニット103、第1段ミキサ105、および第1のプロセッサ99に接続する。受信アンプレグネチャ97の各々を1シンボル長T_s、すなわち256チップだけ遅延ユニット103により遅延させる。遅延ユニット103の出力を、受信シンボルを複素共役値に変換する共役値発生器107に供給する。共役値発生器107の出力を第1のミキサ105に供給し、このミキサ105により上記複素共役値の実部にアンプレグネチャを乗算しアンプレグネチャとレンボル系列ベースの出力系列との間の相関をとる。その和を閾値と比較して、その和が16番目のシンボルの終わりまでの間にその閾値を超えた場合は、レグネチャが検出される。各レグネチャに1回ずつ合計16回の計算が行われるので、あるサンプル時間に閾値を超える累算が2回以上あり得る。その場合、最大値の累算値を正しい値として選択する。

【0057】

上述のレグネチャ相関演算と同時に整合フィルタ79の出力97を第1のプロセッサに供給して各シンボル出力についてのエネルギー値を算出する。算出したエネルギー値の各々をメモリマトリクス101に蓄積する。上述のとおり、シンボル19個の列についてエネルギー値の算出が終わったあと、第2のプロセッサ109がその列についてのエネルギー値を算出し、それを第2のメモリ111に蓄積する。なお、メモリマトリクス101および第2のメモリ111は図示の二つの別個の部品でなく、実際には単一のRAMにより構成する。所定の閾値を超えるエネルギーを復検出力とする。シンボル19個から成る256個のあり得るレグネチャを第2のメモリ111に算出したあと、第3のプロセッサ113が256個のエネルギーレベルを一つずつ正常レグネチャ検出と比較し、各プロセスを相互検証し、正しい受信レグネチャ系列に到達する。

【0058】

複数ドップラーチャネルに対処するために、代替の実施例では上述の四つのケースに基づくアプローチと同様のチャネル分析を行う。ドップラーチャネルに対処するために位相回転を導入する。この位相回転はドップラー効果に起因する位相変動を補正し補償する。m個のドップラーチャネルにおけるコヒーレント検出には $m \times 4 / 16$ 個の復調出力を生ずる。これらm個の復調出力のうちの最大値を選択し、それと対応するレグネチャを特定する。

【0059】

受信した系列が $r(t)$ である場合は、19個のサンプル $r(n \cdot T_s)$ ($n = 1, 2, 3, \dots, 19$) が収集された度ごとに、四つのケース、すなわち $n = 1, 2, 3, \dots, 16$ (ケース1)、 $n = 2, 3, 4, \dots, 17$ (ケース2)、 $n = 3, 4, 5, \dots, 18$ (ケース3)、および $n = 4, 5, 6, \dots, 19$ (ケース4) を検出する。ドップラーを解消するために、m個のドップラーチャネルに対応するN個の互いに異なる位相回転で16個のレグネチャと各ケースとの相関をとる。これら位相回転との相関の出力は次式、すなわち

【式10】

【0060】

$$y_{ik} = \sum_{n=1}^{16} |r(n\Delta t) \times \bar{s}_i \times \exp(-j \cdot 2\pi f_{0k} n\Delta t)|^2, \text{Equation 10}$$

で与えられる。ここで $i=1, 2, 3, \dots, 16$; $k=1, 2, 3, \dots, m$; $2\pi f_{0k}$ は i 番目のドップラーチャンネルの位相変移; S_i は $i=1, 2, 3, \dots, 16$ についてあり得るシグネチャである。

【0061】

五つのドップラーチャンネルの周波数搬送の例は: $(f_{01}, f_{02}, f_{03}, f_{04}, f_{05}) = (-200\text{Hz}, -100\text{Hz}, 0, 100\text{Hz}, 200\text{Hz})$ で相互間の間隔は 100Hz である。各ケースは $m \times 16$ 個の仮説出力を生ずる。四つのケースで $m \times 16 \times 4$ 個の仮説出力を生ずる。これら $m \times 16 \times 4$ 個の仮説出力との対応の最も大きいプリアンプルシグネチャを選択する。

【0062】

この発明の実施例により構成した複数ドップラーチャンネル間のコヒーレント検出を用いた受信機を図12Aおよび図12Bに示す。図12Aにおいて、受信したRACH77を窓フィルタ79に加えて拡散符号(256チップ)との相測をとる。上述のとおり、256チップごとに窓フィルタから一つのシンボルが出力され、19個のシンボル出力が集められてメモリマトリクス101に蓄積されるまでその出力が続く。これら19個のシンボル出力のうち16個の互いに連続したシンボル出力をアセンブルして四つのケースを形成する。

【0063】

これら16個の連続サンプルの四つのケースの各々をプリアンプル相関器119で m 個のドップラーチャンネル上の16個のプリアンプル系列の各々との間で相関をとる。これによって生じた $m \times 16 \times 4$ 個の仮説値を第2のメモリ121に蓄積する。これら $m \times 16 \times 4$ 個の仮説値のうちエネルギーの最も大きいケースを選択し123、それに対応するプリアンプルシグネチャを特定する。図12Bはあるプリアンプル系列とあるドップラーチャンネル(すなわち周波数搬送 f_{0k} ($k=1, \dots, m$))を有するチャンネルとの間のプリアンプル相関器の詳細なブロック図を示す。

【0064】

この発明の代替的实施例は図13に示した 16×16 シグネチャマトリクスに基づいている。この実施例を用いる際には、図13のシグネチャマトリクスの基底符号化により新たなシグネチャ組を形成する。この符号化規則は次のとおりである。すなわち、まず $S(i, k)$ 、 $M(i, k)$ および $R(i, k)$ をつぎのとおり定義する。

$S(i, k)$ = シグネチャ i の k 番目の要素;

$M(i, k)$ = ここに提案する新たな被伝送シグネチャ組の k 番目の要素;

$R(i, k)$ = ここに提案する新たなコピー組の k 番目の要素、受信機蓄積用

次に、これら要素を次のとおりマップする。すなわち、 $A \cdot \cdot \cdot > 1$ および $B \cdot \cdot \cdot > j$ = $\text{sqrt}(-1)$ にマップし、 $M(i, 0) = A = 1$ および $R(i, 0) = A = 1$ にセットする。 $k=1$ 乃至 16 について次式を得る。すなわち、

$$M(i, k) = M(i, k-1) \times S(i, k) \quad (\text{式11})$$

$$R(i, k) = S^*(i, k)$$

(式12)

ここで、*は複素共役値を表す。

【0065】

$S(i, k) = 1$ の場合、 $R(i, k) = 1$

$S(i, k) = j$ の場合、 $R(i, k) = -j$

この規則は図14に示すとおり総括でき、この図において左側は $M(i, k)$ の四つのと

り得る値を表し、第1行は $S(1, k)$ の四つとり得る値を表す、図15は未符号化の原系列および差動符号化による変換後の系列を示す。

【0066】

受信側ではこれらシンボルを差動符号化する。D(0)=1から始めて、復号化済みシンボルの k ($k=0, \dots, 15$)が受信符号化済みシンボル $C(k)$ で次のとおり与えられる。

【0067】

$$D(1, k) = C(1, k) \times C(1, k-1)^* \quad (\text{式13})$$

次にアリアンブルシグネチャとの相関をとり、 $\text{Sum}(1) = 0$ が得られる。1=0乃至15について、次式を示す。

$$\text{Sum}(1) = \text{Sum}(1) + D(1, k) \times R(1, k) \quad (\text{式14})$$

が得られる。新たな搬送波シグネチャ全体を図16に示す。AをBに置換しBをAに置換することによって上述の手法と同じ手法を図13にアリアンブルシグネチャに適用できる。

【産業上の利用可能性】

【0068】

CDMA技術を用いた第3世代携帯電話システムの通話品質の改善およびシステム容量拡大に利用できる。

【図面の簡単な説明】

【0069】

【図1】従来技術によるCDMA通信システムの単純化したブロック図。

【図2】16種の非コヒーレントRACHシグネチャの表。

【図3】並列RACH試行の送信タイミングを示すタイミング図。

【図4】図4Aは第1のシンボル間隔中に受信した16シンボルRACHアリアンブルシグネチャを示すタイミング図、図4Bは第2のシンボル間隔中に受信した16シンボルRACHアリアンブルシグネチャを示すタイミング図、図4Cは第3のシンボル間隔中に受信した16シンボルRACHアリアンブルシグネチャを示すタイミング図、図4Dは第4のシンボル間隔中に受信した16シンボルRACHアリアンブルシグネチャを示すタイミング図。

【図5】CDMA通信システムの詳細なブロック図。

【図6】図6Aは従来技術によるランダムアクセスチャネルアリアンブルデコードのシステム図、図6Bはこの発明により構成したランダムアクセスチャネルアリアンブル検出器。

【図7A】シンボルメモリマトリクスの図。

【図7B】アリアンブルシグネチャの検出手順の流れ図。

【図7C】距離アンビギュエティ解消の手順の流れ図。

【図8】距離アンビギュエティ解消のための受信アリアンブルシグネチャの四つの可能性ある組合せを示す表。

【図9】直交性と距離アンビギュエティとの関係を示す表。

【図10】16種の非コヒーレントRACHシグネチャの表。

【図11】非コヒーレントアリアンブル検出器のシステム図。

【図12】図12Aは複数ドップラーチャネル補正用のコヒーレントRACHアリアンブル検出器のシステム図、図12Bはアリアンブル相関器の詳細図。

【図13】この発明の代わりの実施例。

【図14】この発明の上記代わりの実施例の符号化規則。

【図15】未符号化系列およびその差動符号化系列への変換。

【図16】図15の系列の搬送波シグネチャ。

【符号の説明】

【0070】

25 CDMA通信システム

27	送信機
29	受信機
31	シグナルプロセッサ
33	入力データ
35	前向き誤り訂正符号器
41a, 41b	QPSKシンボルストリーム
43a, 43b	複素変調雑音系列
45a, 45b	デジタルスペクトラム拡散信号
46a, 46b, 57a, 57b	ミキサ
53	コンバイナ
59a, 59b	中間周波数信号
61	フィルタ
62a, 62b	ミキサ
67	シグナルプロセッサ
79	整合フィルタ
81	プリアンプル復調器
85	ピーク検出器
87	タイミング推算器
89	RAKEユニット
101	ランダムアクセスチャネル (RACH) 検出器
103	遅延手段
106	実部選択器
107	複素共役値プロセッサ
200	プリアンプルレグネチャ復検定手順
201	マトリクスにデータを格納する
202	各行内のエネルギーの和を算出して蓄積する
204	第1行についての和を所定の閾値と比較する
206	和は閾値よりも大きい?
208	検出と印をつける
210	各行についての和を比較する
212	次の行についての和に変わる
214	距離アンビギュイティを解消する
216	候補を出力する
300	距離アンビギュイティを解消する手順
301	初めの16個の位置に変わる (k=0)
302	それら16個の位置についてのエネルギー値の和を算出する
304	エネルギー値の和を蓄積する
306	全位置についての和を算出した? (すなわち k=3 成立?)
308	次の16個の位置に変わる
312	和を互いに比較して最大値を示す位置を判定する
314	和の最大値に対応するものの順を出力する

FIG. 6a

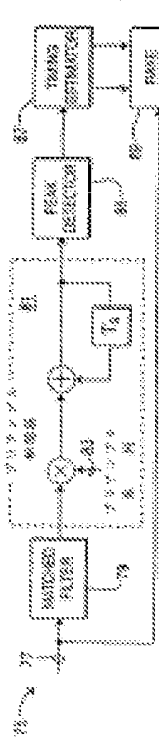


FIG. 6a
PRIOR ART

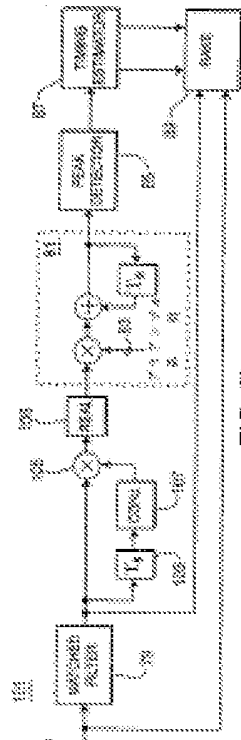


FIG. 6b

FIG. 7a

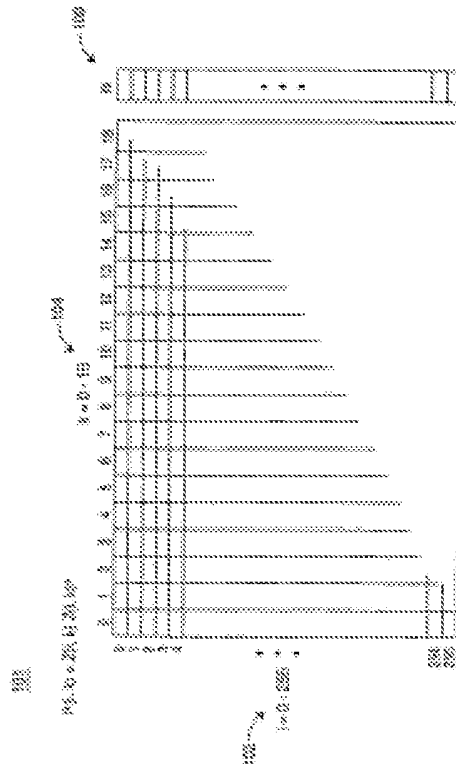


FIG. 7a

FIG. 7b

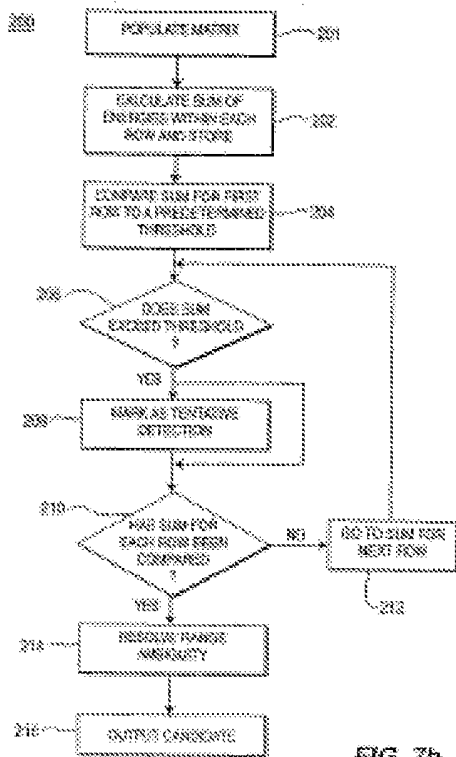


FIG. 7b

FIG. 7c

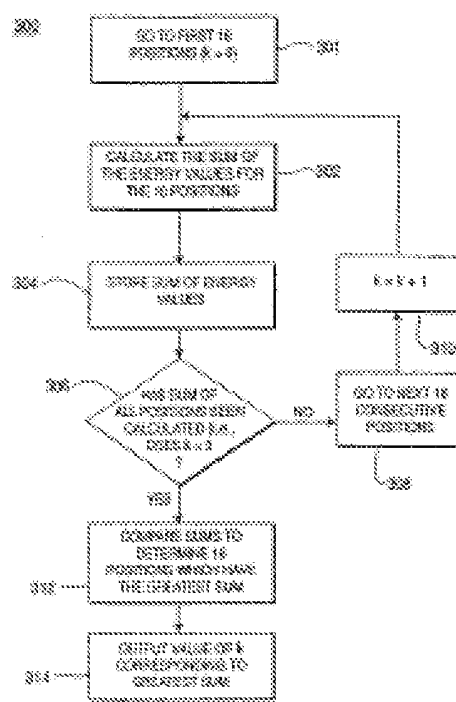


FIG. 7c

(31)優先権主張番号 60/129,177

(32)優先日 平成11年4月14日(1999.4.14)

(33)優先権主張国 米国(US)

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Pターム(参考) 5002 5002 5003 5005 5005

Electronic Acknowledgement Receipt

EFS ID:	11682132
Application Number:	12303947
International Application Number:	
Confirmation Number:	1730
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Customer Number:	35884
Filer:	Harry Sung Lee/Diana Kim
Filer Authorized By:	Harry Sung Lee
Attorney Docket Number:	2101-3596
Receipt Date:	21-DEC-2011
Filing Date:	07-JUL-2010
Time Stamp:	17:55:43
Application Type:	U.S. National Stage under 35 USC 371

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1	Information Disclosure Statement (IDS) Form (SB08)	2101-3596_120911_IDSForm.pdf	612413 <small>7e0f16d29f65865749b6e07c3d5d12bc30e12c15</small>	no	4

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3	Foreign Reference	F2_JP2004274794.pdf	1107072	no	21
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	12303947
	Filing Date	2010-07-07
	First Named Inventor	Yeong Hyeon Kwon
	Art Unit	2478
	Examiner Name	Khajuria, Shripal K.
	Attorney Docket Number	2101-3596

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	3	2004512728	JP		2004-04-22	Samsung Electronics Co., Ltd.		<input type="checkbox"/>

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Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	Khajuria, Shripal K.
Attorney Docket Number	2101-3596

4	04-035332	JP		1992-02-06	Sanyo Electric Co., Ltd.	<input type="checkbox"/>
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Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	Khajuria, Shripal K.
Attorney Docket Number	2101-3596

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- See attached certification statement.
- The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.
- A certification statement is not submitted herewith.

SIGNATURE

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	/David G. Majdali/	Date (YYYY-MM-DD)	2011-12-22
Name/Print	David G. Majdali	Registration Number	53,257

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Bibliographic data: JP2005260337 (A) — 2005-09-22

DEMODULATION CIRCUIT AND RADIO COMMUNICATION SYSTEM

Inventor(s): MATSUDA KEISUKE; OKUBO TAKASHI; HORI JINICHI; TAKADA KAZUYUKI ±

Applicant(s): RENESAS TECH CORP ±

Classification:
 - **international:** H04J11/00; H04L25/02; H04L27/14; H04L27/26; H04L27/38; H04L27/00; (IPC-1-7): H04J11/00
 - **European:** H04L25/02C5; H04L27/26M5C3; H04L27/38A

Application number: JP20040065567 20040309

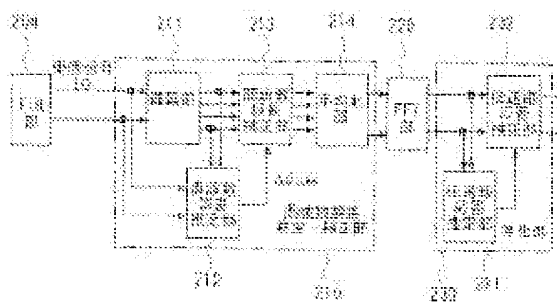
Priority number (s): JP20040065567 20040309

Also published as: US2005213689 (A1)

Abstract of JP2005260337 (A)

PROBLEM TO BE SOLVED: To provide a semiconductor integrated circuit for communication having a built-in OFDM demodulation circuit capable of reducing a delay time from packet reception to demodulated data output, and a radio communication system employing the same. ;

SOLUTION: The demodulation circuit demodulates a reception signal of a packet modulated in an orthogonal frequency division multiplexing system and containing a preamble having two or more continuous fixed signal sequences. The circuit is provided with a frequency error estimation/correction processing function (210) for estimating a frequency error of a reception signal using the received preamble to correct the reception signal, a fast Fourier transform processing function (FFT section 220) for transforming time axis information into frequency axis information from the received reception signal, a transmission path response estimation/correction processing function (230) for estimating the status of a transmission path from the transformed signal to correct the reception signal, and an averaging processing function (214) for averaging the reception signal after the frequency error correction. The circuit is configured so that the averaging processing may be executed before execution of the fast Fourier transform processing. ; COPYRIGHT: (C) 2005,JPO&NCIPI



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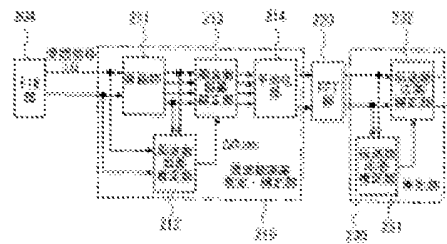
(54) 【発明の名称】 復調回路および無線通信システム

(57) 【要約】

【課題】 パケット受信から復調データ出力までの遅延時間を小さくできるOFDM復調回路を内蔵した通信用半導体集積回路とそれを用いた無線通信システムを提供する。

【解決手段】 直交周波数分割多重方式で変調され、2以上の副搬送信号系列が連続したプリアンブルを含むパケットの受信信号を復調する復調回路において、受信した前記プリアンブルを用いて受信信号の周波数誤差を推定し受信信号を補正する周波数誤差検定・補正処理機能(210)と、補正された受信信号から時間軸情報を周波数軸情報に変換する高速フーリエ変換処理機能(FDF部220)と、変換された信号から伝送路の状態を推定し受信信号を補正する伝送路応答推定・補正処理機能(230)と、周波数誤差補正後の受信信号の平均を取る平均化処理機能(214)とを設け、前記平均化処理が前記高速フーリエ変換処理の前に実行されるように構成した。

【図1】 図4



【特許請求の範囲】

【請求項1】

前記周波数分割多重方式で変調され、2以上の固定信号系列が連続したプリアンプルを含むパケットの受信信号を復調する復調回路であって、

受信した前記プリアンプルを用いて受信信号の周波数誤差を推定し受信信号を補正する周波数誤差推定・補正処理機能と、

補正された受信信号を時間軸情報から周波数軸情報の信号に変換する高速フーリエ変換処理機能と、

変換された信号から伝送路の状態を推定し受信信号を補正する伝送路応答推定・補正処理機能と、

周波数誤差補正後の受信信号の平均を取る平均化処理機能とを備え、

前記平均化処理が前記高速フーリエ変換処理の前に行われるように構成された復調回路が1つの半導体チップに形成されてなることを特徴とする通信用半導体集積回路。

【請求項2】

受信したプリアンプルを所定時間だけ遅延する遅延手段を備え、

該遅延手段により遅延されたプリアンプルと該プリアンプルの受信後に受信したプリアンプルとに基づいて周波数誤差推定・補正処理が行われるように構成されていることを特徴とする請求項1に記載の通信用半導体集積回路。

【請求項3】

前記周波数誤差推定・補正処理により補正された後のプリアンプルを遅延する第2の遅延手段を備え、

連続したプリアンプルを周波数誤差推定・補正処理により順次補正し、

補正されたプリアンプルを前記第2の遅延手段で遅延させ、

該遅延されたプリアンプルと前記周波数誤差推定・補正処理により補正されたプリアンプルとを用いて前記平均化処理を行い、該平均化処理が前記高速フーリエ変換処理の前に行われるように構成されていることを特徴とする請求項2に記載の通信用半導体集積回路。

【請求項4】

受信したプリアンプルを保持するメモリ回路を備え、

該メモリ回路に格納されているプリアンプルと該プリアンプルの受信後に受信したプリアンプルとに基づいて周波数誤差推定・補正処理が行われるように構成されていることを特徴とする請求項1に記載の通信用半導体集積回路。

【請求項5】

前記パケットは前記プリアンプルとシグナルとデータで構成され、

前記シグナルは前記データのデータ配送レートとデータ長を指し示す情報を含み、

前記平均化処理は前記シグナルが入力されている間に行われるように構成されていることを特徴とする請求項1ないし4に記載の通信用半導体集積回路。

【請求項6】

前記平均化処理は、2つのプリアンプルを加算して2で割る信号ことを特徴とする請求項1ないし4に記載の通信用半導体集積回路。

【請求項7】

前記平均化処理は、連続する2つのプリアンプルの時間平均を取る処理であることを特徴とする請求項1ないし4に記載の通信用半導体集積回路。

【請求項8】

受信信号を順次遅延させる直列形態の複数の遅延段と、

各遅延段に対応された遅延算器とからなり受信信号から帯域外の周波数成分を除去する有限インパルス応答型フィルタを備え、

前記有限インパルス応答型フィルタは受信信号が通過する前記遅延段の数が切替え可能に構成されていることを特徴とする請求項1ないし7に記載の通信用半導体集積回路。

【請求項9】

前記有限インパルス応答型フィルタは、いずれか1または2以上の前記遅延段を通過せずに受信信号を伝達させるバイパス経路と、該バイパス経路を通過した受信信号または前記いずれか1または2以上の前記遅延段を通過した受信信号のいずれか一方を選択する選択手段を備えていることを特徴とする請求項8に記載の通信用半導体集積回路。

【請求項10】

前記高速フーリエ変換処理機構は、バタフライ演算の乗率変算が可能な第1演算手段と、該第1演算手段による演算結果を保持するメモリ回路と、高速フーリエ変換処理のいずれか1のステージの演算が可能な第2演算手段とを備え、

前記第2演算手段の演算は前記第1演算手段の演算よりも単純な演算であることを特徴とする請求項1をいし9に記載の通信用半導体集積回路。

【請求項11】

前記第1演算手段は、入力信号に基づく第1ステージの演算と前記メモリ回路に保持されている演算結果に基づく第2ステージの演算とを順次実行し、前記第2演算手段は前記第1演算手段における第2ステージの演算と並行して第3ステージの演算を実行するように構成されていることを特徴とする請求項10に記載の通信用半導体集積回路。

【請求項12】

直交周波数分割多重方式で変調され、2以上の固定信号系列が連続したプリアンブルを含むパケットの受信信号を復調する復調回路であって、

受信した前記プリアンブルを用いて受信信号の周波数誤差を推定し受信信号を補正する周波数誤差推定・補正処理機能と、

補正された受信信号から時間軸情報を周波数軸情報に変換する高速フーリエ変換処理機能と、

変換された信号から伝送路の状態を推定し受信信号を補正する伝送路応答推定・補正処理機能と、

周波数誤差補正後の受信信号の平均を取る平均化処理機能と、受信信号から帯域外の周波数成分を除去するためのフィルタとを備え、

前記フィルタは受信信号を順次遅延させる直列形態の複数の遅延段と、前記各遅延段に対応された掛け算器とからなり受信信号が通過する前記遅延段の数が切替え可能に構成された復調回路が1つの半導体チップに形成されてなることを特徴とする通信用半導体集積回路。

【請求項13】

前記フィルタは、いずれか1または2以上の遅延段を通過せずに受信信号を伝達させるバイパス経路と、該バイパス経路を通過した受信信号または前記いずれか1または2以上の前記遅延段を通過した受信信号のいずれか一方を選択する選択手段を備えていることを特徴とする請求項12に記載の通信用半導体集積回路。

【請求項14】

前記パケットには、第1の固定信号系列が連続した第1のプリアンブルに続いて前記第1の固定信号系列よりも長い第2の固定信号系列が連続した第2のプリアンブルが含まれ、

前記フィルタは前記第1のプリアンブルを処理する際に受信信号が通過する前記遅延段の数が減少するように制御されることを特徴とする請求項12または13に記載の通信用半導体集積回路。

【請求項15】

直交周波数分割多重方式で変調され、2以上の固定信号系列が連続したプリアンブルを含むパケットの受信信号を復調する復調回路であって、

受信した前記プリアンブルを用いて受信信号の周波数誤差を推定し受信信号を補正する周波数誤差推定・補正処理機能と、

補正された受信信号から時間軸情報を周波数軸情報に変換する高速フーリエ変換処理機能と、

変換された信号から伝送路の状態を推定し受信信号を補正する伝送路応答推定・補正処理機構と。

周波数誤差補正後の受信信号の平均を取る平均化処理機能とを備え。

前記高速フーリエ変換処理機構は、バタフライ演算の複素乗算が可能な第1演算手段と、該第1演算手段による演算結果を保持するメモリ回路と、高速フーリエ変換処理のいずれかのステージの演算が可能な第2演算手段とを備え。

前記第2演算手段の演算は前記第1演算手段の演算よりも単純な演算である復調回路が1つの半導体チップに形成されてなることを特徴とする通信用半導体集積回路。

【請求項16】

前記第1演算手段は、入力信号に基づく第1ステージの演算と前記メモリ回路に保持されている演算結果に基づく第2ステージの演算とを順次実行し、前記第2演算手段は前記第1演算手段における第2ステージの演算と並行して第3ステージの演算を実行するように構成されていることを特徴とする請求項15に記載の通信用半導体集積回路。

【請求項17】

請求項1ないし16に記載の復調回路と、

受信信号をデジタル信号に変換して前記復調回路に入力するA/D変換回路と、

直交周波数分割多重方式の変調を行なう変調回路と、

該変調回路により変調された信号をアナログ信号に変換して出力するD/A変換回路とが1つの半導体チップに形成されてなることを特徴とする通信用半導体集積回路。

【請求項18】

請求項1ないし17に記載の通信用半導体集積回路と、

受信信号をベースバンド信号に周波数変換する周波数変換回路および周波数変換された受信信号を所定のレベルに増幅する可変利得増幅回路と送信信号を高周波信号に周波数変換する周波数変換回路とを有する高周波用半導体集積回路とを備え。

前記可変利得増幅回路は前記通信用半導体集積回路から供給されるゲイン設定信号に基づいて増幅率が設定されるようにされていることを特徴とする無線通信システム。

【請求項19】

前記高周波用半導体集積回路は受信した前記パケットに含まれるプリアンプルに基づいて受信信号の強度を検出して外部へ検出信号を出力する受信強度検出回路を備え。

前記通信用半導体集積回路は前記受信強度検出回路から出力された検出信号に基づいて前記可変利得増幅回路のゲインを決定しゲイン設定信号を生成して出力するゲイン設定回路を備えることを特徴とする請求項18に記載の無線通信システム。

【請求項20】

前記ゲイン設定回路は前記復調回路に入力された受信信号に基づいて受信信号の強度を検出して前記可変利得増幅回路のゲインを決定しゲイン設定信号を生成して出力する機能を備え。

前記受信強度検出回路から出力された検出信号に基づいて前記可変利得増幅回路のゲインを粗く設定するための第1ゲイン設定信号を生成して出力した後、前記復調回路に入力された受信信号に基づいて前記可変利得増幅回路のゲインを精密に設定するための第2ゲイン設定信号を生成して出力することを特徴とする請求項19に記載の無線通信システム。

【発明の詳細な説明】

【技術分野】

【0001】

本発明は、OFDM(Orthogonal Frequency Division Multiplexing:直交周波数分割多重)変調方式を用いた復調回路および無線通信システムに関し、特に受信処理遅延時間の短縮に有効な技術に関するものである。

【背景技術】

【0002】

近年、無線通信やデジタル放送の送信信号の変調方式の一つにOFDM変調方式を用いるものがある。OFDM変調方式は直交性を有する複数のキャリアを用いるデジタル変調方

式であるため、一般にマルチパス干渉に対して優れた特性を有している。しかし、複数のキャリアを用いる為に関波数誤差による信号歪みが大きく、高精度の周波数同期が必要である。また、マルチパス干渉に対して優れた特性を生かすためには、各サブキャリアの伝送路応答（フェースなど周囲の状況に応じて変化する受信状態）を適切に補正する必要がある。

【0003】

また、OFDM変調方式を採用する無線LANなどはデータの伝送をパケット方式で行うが、パケット伝送では高速にパケットの検出や同期処理を行う必要がある。そのため、一般にOFDMパケット信号では、パケット先頭に既知パターン（繰り返し信号（プリアンブル信号）以降プリアンブルと記述）が付け加えられており、プリアンブルを用いてパケット検出、同期処理、伝送路応答補正が行われる。一例として図2に、5GHz帯無線LANの規格であるIEEE802.11aで規定されているパケットの構成を示す。

【0004】

図2に示されているように、IEEE802.11aパケットは、ショートプリアンブル部SPA（11～10）、ロングプリアンブル部LPA（T1、T2）、シグナル部（SIGNAL）、データ部（DATA）からなる。このうち、ショートプリアンブル部SPAは、0.8 μ s期間の固定パターンが10回繰り返されており、主にタイミング検出、受信同期処理に用いられる。ロングプリアンブルLPAは3.2 μ s期間の固定パターンが2回繰り返されている。ロングプリアンブルLPAの総幅32サンプル分（1.6 μ s）のコピーが、ガードインターバルGIとしてロングプリアンブルの先頭に付加され、全体で8 μ sの長さときており、主に周波数誤差補正、伝送路応答補正等に用いられる。シグナル部（SIGNAL）は、これに続いて送られるデータ部（DATA）のデータ転送レートとデータ長等が符号化されたシンボルで、データ部（DATA）とともに、そのシンボルの総幅16サンプル分（0.8 μ s）のコピーがガードインターバルGIとしてシンボルの先頭に付加され、それぞれ全体で4 μ sの長さとなっている。図2のようなパケット構成を持つ無線通信信号に関する伝送路応答推定方式については、例えば非特許文献1に開示されている。

【非特許文献1】社団法人電子情報通信学会発行、信学技報TECHNICAL REPORT OF IEICE REX2000-34(2000-06)「OFDM通信システムにおける伝送路推定方式に関する検討」

【発明の開示】

【発明が解決しようとする課題】

【0005】

図1にはOFDM変調信号復調回路のこの発明に先立って本発明者によって検討された構成が示され、図3にはこの発明に先立って本発明者によって検討された復調回路における周波数誤差推定・補正部210と等化部230の詳細が示されている。アンテナ201で受信されたパケットはRF部202でベースバンド信号にダウンコンバートされ、A/D変換部203にてデジタル信号に変換される。その後、受信信号はP1R（Pulse Repetition or Response:有限インパルス応答型）フィルタ204にて帯域外の高周波成分が除去される。RF部202は、受信信号のレベルがA/D変換部203のダイナミックレンジに入るようにAGC（Auto Gain Control:自動利得制御）部205によってゲイン設定が行われる。

【0006】

同期部206では、デジタル信号に変換された受信パケットのプリアンブルの繰り返しパターンを用いて、同期検出部207により同期位置検出および同期処理を行い、周波数誤差推定・補正部210により周波数誤差の推定および周波数誤差補正を行う。また、この時点でガードインターバルの除去が行われる。FFT（Fast Fourier Transform:高速フーリエ変換）部220では、受信信号を時間軸情報から周波数軸情報へ変換する処理を行う。

【0007】

等化部230では、周波数軸情報に変換された受信プリアンブルパターンと既知プリアンブルパターンとを比較することで伝送路応答を推定し、伝送路応答の補正を行う。この

時、通常受信パケットには伝送遅延帯域ノイズの漏れが含まれた状態で受信されるため、単純に現知アリアンアルパケーンを比較するとノイズ成分が伝送遅延帯域推定誤差として現れ、伝送遅延帯の幅を正確に行うことができない。そのため、アリアンアルパケーンが複数回繰り返し送られていることを利用して、図3に示すようにFFT第220で遅延遅延帯幅に一致させた受信アリアンアルパケーンを平均化部234で平均化してノイズ低減を行い、伝送遅延帯推定部231での推定誤差を少なくする。

【0009】

図1及び3で示された観測方式では、パケットが受信されてから伝送遅延帯の幅が付けられるまでの遅延時間的大小、アパケーン幅で受信完了してから、復調したパケットに対する送信を開始までの時間が長くなるという不具合がある。以下に、上記の不具合を解消する上で問題となる課題を説明する。

【0010】

図11(図)にこの発明に先立って発明者によって観測されたOFDM観測信号復調部でのタイムシンクサーチを示す。伝送遅延帯幅推定出力まで遅延時間Tdを大きくしている観測は、第一に、遅延遅延帯幅推定、補正部210で繰り返し処理パケーン(アリアンアルパケーン)に対する補正を継続に行っていること、第二に、遅延遅延帯幅推定、補正部210で遅延遅延帯を推定するために繰り返し処理パケーンを受信パケーン復調部211で一様保持し、さらに平均化部230で伝送遅延帯の推定を行う際に繰り返し処理パケーンを平均化する為、に平均化部234で保持していること、にある。

【0011】

第二の課題は、以下の点にある。上述したように、パケットを受信すると自動判別遅延部でA/D変換のタイムシンク・シンクに似るようなタイム設定が行われるが、パケット受信からタイム設定までの時間が大きくなると、そのタイムシンク・シンクを無視した受信パケーンで復調することになる。そのため、より早くパケットを受信したことを検出し、適正なタイム設定をすることが重要となる。一般に、受信信号の検知はRSSI(Rceived Signal Strength Indicator:受信信号強度検知)や受信信号を用いた電力計算等により行われる。受信パケーンは、同期検出、遅延遅延帯幅推定や受信信号を用いた電力計算等を用いて電力計算が行われる。この時、FIRフィルタのタップ数(遅延素子と掛け算素子の数)を多くすると、受信信号が通過する遅延素子の数が多くなるため、信号がフィルタに入力されてから出力されるまでの遅延時間が大きくなりパケット抽出までの時間も大きくなる。遅延タップ数を少なくすると遅延時間は減りすが、フィルタ性能が劣化して十分な観測処理ができなくなる。

【0012】

第三の課題は、以下の点にある。FFT(高速フーリエ変換部)では一般にパワースペクトルが行われるが、観測遅延を判定して処理を行うには図19のような構成が採用される。すなわち、時間遅延領域のチャータは一般にパワースペクトル検出部メモリ221に格納され、遅延に必要なチャータが抽出してヒタタ222号を辿ってパワースペクトル検出部222でパワースペクトル検出を行い、その遅延検出を演算結果格納部メモリ223に格納する(第1ステップ)。次にヒタタ225を切り替えて演算結果格納部メモリ223からチャータを読み出し、再びパワースペクトル検出部222で演算を行い、演算結果を演算結果格納部メモリ223に格納する(第2ステップ)。さらに格納したチャータから、もう一度パワースペクトル検出部222で演算を行い、その演算結果を遅延遅延領域方向のチャータとして出力する(第3ステップ)。従って、図19(図)に示すように、各ステップの処理をパワースペクトルで行うことになるが、処理時間が大きい。パワースペクトル検出部222は加算器と乗算器等によって構成されており、処理時間を抑える為には、各ステップの処理を並列処理する必要があるが、並列処理をするには遅延の同期検出と検出遅延領域等が必要であり、同期遅延が確保できなくなる。

【0013】

本発明の目的は、上記のような課題を解決することで、パケット受信から観測パケーン抽出までの遅延時間を小さくできるOFDM観測遅延帯幅推定部を内蔵した通信端末を構成するそ

れを用いた無線通信システムを提供することにある。

この発明の新記ならびにそのほかの目的と新規な特徴については、本明細書の記述および添付図面から明らかになるであろう。

【課題を解決するための手段】

【0013】

本願において開示される発明のうち代表的なものの概要を説明すれば、下記のとおりである。

すなわち、本出願に係る発明は、固定信号系列を一区間とし、該固定信号系列の少なくとも二区間以上の繰り返しを含むプリアンプルを送信パケットに存在するOFDM変調信号の伝送システムに適用され、受信側で前記プリアンプルの受信信号を用いて周波数誤差の推定と補正を行う周波数誤差補正機能と、前記プリアンプルの受信信号を用いて伝送路応答の推定と補正を行う伝送路応答補正機能を有するOFDM復調回路において、受信したプリアンプルを遅延させる為の遅延手段と、受信したプリアンプルと前記遅延手段を用いて遅延させたプリアンプルとから周波数誤差推定を行い、該推定信号をもとに周波数誤差補正を行う周波数誤差補正機能と、前記周波数誤差補正機能で補正した受信プリアンプルをFFT処理前に平均化処理する平均化手段と、該平均化処理されたプリアンプルのFFT処理結果に基づいて伝送路応答の推定を行い、該伝送路応答の推定結果からOFDM変調信号を復調する伝送路応答補正機能とを有することを特徴とする。

【0014】

上記した手段によれば、プリアンプルの平均化処理が時間軸において行われ、周波数軸情報に変換されるのは平均化された後のプリアンプルとなるため、パケットが受信されてから伝送路応答補正までの遅延時間を短縮することができる。前記周波数誤差補正機能は、遅延手段を用いて遅延させたプリアンプルとその後受信したプリアンプルに対して前記周波数誤差推定に基づいて同時に周波数誤差補正を行ってから平均化するように構成（図4）しても良いし、前記遅延手段とは別個に周波数誤差補正された受信プリアンプルを遅延させる為の第2の遅延手段を設け、複数のプリアンプルを順次別々に周波数誤差補正し、前のプリアンプルのサンプルを第2の遅延手段で遅延して、後から受信したプリアンプルのサンプルの補正歪みと同時に平均化するように構成（図12）しても良い。

【0015】

また、本出願に係る発明は、受信したプリアンプルを保持する為の記憶手段と、受信したプリアンプルと記憶手段を用いて保持したプリアンプルとから周波数誤差推定を行い、該推定信号をもとに周波数誤差補正を行う周波数誤差補正機能と、前記周波数誤差補正機能で補正した受信プリアンプルをFFT処理前に平均化処理する平均化手段と、該平均化処理されたプリアンプルのFFT処理結果に基づいて伝送路応答の推定を行い、該伝送路応答の推定結果からOFDM変調信号を復調する伝送路応答補正機能とを有することを特徴とする。受信したプリアンプルを保持する記憶手段を設けることによって、記憶したプリアンプルを任意のタイミングで読み出すことができるため、時間的に離れたプリアンプルに基づいて周波数誤差推定を行うことができるようになり、これによってより精度の高い推定が可能となる。

【0016】

さらに、本出願に係る発明は、受信信号のゲイン調整を行うゲイン調整手段と、ゲイン調整された受信信号をアナログ信号からデジタル信号に変換するデジタル変換手段と、前記デジタル変換された受信信号の帯域外信号を除去する有限インパルス応答型フィルタ（FIRフィルタ）と、該FIRフィルタの出力から前記ゲイン調整手段を用いて自動利得制御を行う自動利得制御を有し、利得制御を行う前段で上記FIRフィルタの段数を切り替えることを特徴とする。フィルタの段数を切り替え可能に構成することで、自動利得制御の際にFIRフィルタの段数を減らして遅延時間を少なくすることができ、それによって利得制御に対する時間を短縮することができるようになる。

【0017】

さらにまた、本出願に係る発明は、前記周波数誤差補正を行った受信信号を時間軸情報

から周波数軸情報に変換する高速フーリエ変換 (FFT) 処理機能を有し、該FFT処理にバタフライ演算を用い、バタフライ演算の一部を並列に実行することを特徴とする。FFT処理におけるバタフライ演算は、複雑な演算を行うステージと単純な演算を行う複数のステージからなるので、そのうち演算が複雑なステージは共通の演算回路を用いて時分割で実行し、演算が単純なステージは専用の演算回路を用いて実行することで、回路規模の増加を抑えつつ、処理時間を短縮することができる。

【発明の効果】

【0018】

本願において開示される発明のうち代表的なものによって得られる効果を簡単に説明すれば下記のとおりである。

パケットが受信されてからベースバンド信号に変換された後、復調された信号が得られるまでの遅延時間を短縮することができる。

【発明を実施するための最良の形態】

【0019】

以下、本発明を、一例としてIEEE802.11a規格に準拠した無線LANシステムを構成するOFDM復調回路に適用した場合の実施例を示す。

【0020】

(実施例1)

図4は、OFDM復調回路の第1の実施例を示す。本実施例のOFDM復調回路は、この発明に先立って本発明者によって検討されたOFDM復調回路と同様に、A/D変換された受信信号I、Qから帯域外の高周波成分を除去するFIRフィルク204と、周波数誤差の推定と補正を行う周波数誤差推定・補正部210と、受信信号を時間軸情報から周波数軸情報に変換するFFT部220と、周波数軸情報に変換された受信パケットのアリアンブルパターンと参照アリアンブルパターンとを比較することで伝送路応答を推定し、伝送路応答の補正を行う等化部230などから構成されている。

【0021】

周波数誤差推定・補正部210は、遅延差子で構成され受信した受信パケットのショートアリアンブルを16サンプル間隔だけ遅延させる遅延部211と、遅延されたショートアリアンブルのパターンと続いて受信されたショートアリアンブルのパターンとから周波数誤差の推定を行う周波数誤差推定部212と、検出された周波数誤差値と遅延されたショートアリアンブルのパターンおよび続いて受信されたショートアリアンブルのパターンとから周波数誤差の補正を行う周波数誤差補正部213と、補正後の受信信号の時間平均を取る平均化部214とから構成されている。

【0022】

図5に周波数誤差推定部212のブロック図、図6に周波数誤差推定部212の動作タイミングチャートを示す。周波数誤差推定部212は、自己相関演算部121と粗周波数誤差保持部122と周波数誤差演算部123とから構成されている。

【0023】

この実施例の周波数誤差推定部212における周波数誤差の推定は、受信パケットのショートアリアンブルとロングアリアンブルにおいて繰り返しパターン信号間の相関を利用して、繰り返し信号a (16サンプル間隔) だけ遅延させた信号の複素共役信号とその後に続く繰り返し信号との複素乗算を行って位相回転量を検出することで行うことができる。具体的には、16サンプル間隔遅延されたショートアリアンブルの繰り返しパターンt_aと、続いて受信されたショートアリアンブルの繰り返しパターンt_bとからそれらの相関を自己相関演算部121でとる。

【0024】

ここで、自己相関値は、16サンプル間隔遅延させたショートアリアンブルの受信信号I、Qをそれぞれshort00_i,short00_q、続けて受信されてくるショートアリアンブルの受信信号I、Qをそれぞれshort16_i,short16_qとすると、

$$|成分相関値| = (\text{short00}_i \times \text{short16}_i) + (\text{short00}_q \times \text{short16}_q)$$

$$I成分相関値: (short00_i \times short16_q) - (short00_q \times short16_i)$$

であり、ノイズの影響を低減する為に、上記相関値を16サンプル分それぞれ加算したものをquad16_i, quad16_qとすると、粗い周波数誤差推定値 $\Delta\theta_{16bits}$ は、

$$\Delta\theta_{16bits} = \arctan(\text{quad}16_q / \text{quad}16_i)$$

で求められる。

【0025】

こうして求められた粗周波数誤差推定値 $\Delta\theta_{16bits}$ は、粗周波数誤差保持部122に格納される。次に、続いて受信されたロングリアンプルT1を遅延部211で64サンプル周期遅延させたものを、続いて受信されてくるロングリアンプルT2とともに自己相関演算部121に入力し、64サンプルの各サンプルから細測を取り、先に推定した粗周波数誤差と合わせて周波数誤差演算部123で、より精密な周波数誤差推定を行う。

【0026】

64サンプル周期遅延させたロングリアンプルの受信信号I, Qをそれぞれlong00_i, long00_qとし、続いて入力されてくるロングリアンプルの受信信号I, Qをそれぞれ、long64_i, long64_qとすると、

$$I成分相関値: (\text{long}00_i \times \text{long}64_i) + (\text{long}00_q \times \text{long}64_q)$$

$$Q成分相関値: (\text{long}00_i \times \text{long}64_q) - (\text{long}00_q \times \text{long}64_i)$$

であり、ノイズの影響を低減する為に、上記相関値を32サンプル分それぞれ加算したものをquad64_i, quad64_qとすると、密周波数推定値 $\Delta\theta_{32bits}$ は、

$$\Delta\theta_{32bits} = \arctan(\text{quad}64_q / \text{quad}64_i) + \alpha(\Delta\theta_{16bits}, \text{quad}64_i, \text{quad}64_q)$$

で求められる。

【0027】

ここで、 $\alpha(\Delta\theta_{16bits}, \text{quad}64_i, \text{quad}64_q)$ は $\Delta\theta_{16bits}, \text{quad}64_i, \text{quad}64_q$ の値によって決まる位相補正値である。こうして求められた周波数誤差推定値 $\Delta\theta_{32bits}$ は周波数誤差補正部213に入力される。

【0028】

図7に周波数誤差補正部213及び平均化部214の構成例を示す。

周波数誤差補正部213は、周波数誤差補正値演算部131と2つの複素乗算器132、133とからなり、前記遅延部211にて64サンプル周期遅延されたロングリアンプルが入力バスA1から一方の複素乗算器132に入力され、続けて受信されたロングリアンプルが入力バスB1から他方の複素乗算器133に入力され、同時に周波数補正が行われる。周波数誤差補正値演算部131では、シンボルタイミングからのサンプル位置を $k(k=0, 1, \dots, 63)$ とすると、一番目のロングリアンプルに対応した周波数誤差補正値A2として $\cos(\Delta\theta_{32bits} \times k)$, $\sin(\Delta\theta_{32bits} \times k)$ を出力し、2番目のロングリアンプルに対応した周波数誤差補正値B2として $\cos(\Delta\theta_{32bits} \times (64+k))$, $\sin(\Delta\theta_{32bits} \times (64+k))$ を出力する。

【0029】

複素乗算器132、133では、補正する前の64サンプル周期遅延のロングリアンプルのサンプル位置 k でのI成分、Q成分をそれぞれlong0_i(k), long0_q(k)とし、補正後の64サンプル周期遅延のロングリアンプルのサンプル位置 k でのI成分、Q成分をそれぞれlong64_i(k), long64_q(k)とすると、

$$\text{long}64_i(k) = \text{long}0_i(k) \times \cos(\Delta\theta_{32bits} \times k) - \text{long}0_q(k) \times \sin(\Delta\theta_{32bits} \times k)$$

$$\text{long}64_q(k) = \text{long}0_i(k) \times \sin(\Delta\theta_{32bits} \times k) + \text{long}0_q(k) \times \cos(\Delta\theta_{32bits} \times k)$$

で周波数誤差の補正がなされる。

【0030】

また、続けて受信されてきたロングリアンプルの補正後のサンプル位置 k でのI成分、Q成分をそれぞれ、long1_i(k), long1_q(k)とし、続けて受信されてきたロングリアンプルの補正後のサンプル位置 k でのI成分、Q成分をlong11_i(k), long11_q(k)とすると、

$$\text{long}11_i(k) = \text{long}1_i(k) \times \cos(\Delta\theta_{32bits} \times (64+k))$$

$$- \text{long}1_q(k) \times \sin(\Delta\theta_{32bits} \times (64+k))$$

$$\begin{aligned} \text{longI}_q[k] = & \text{longI}_i[k] \times \sin(\Delta\theta_{\text{long}} \times (64+k)) \\ & + \text{longI}_q[k] \times \cos(\Delta\theta_{\text{long}} \times (64+k)) \end{aligned}$$

で周波数誤差の補正がなされる。

【0031】

上記周波数誤差補正部213で周波数誤差補正されたそれぞれのロングリアンプルは平均化部214に入力される。平均化部214は、2つの加算器141、142と2つの1/2回路143、144と2つのセレクタ145、146とからなり、周波数誤差補正されたそれぞれのロングリアンプルを4サンプルについて各サンプルタイミング毎に加算器141、142による加算と1/2回路143、144による1/2減算を行うことで平均化し、出力する。

【0032】

ロングリアンプルに続くシグナルシンボル51検出、データシンボル61検出は平均化処理が不要の為、平均化したロングリアンプルを出力した以降は、入力バスB1からの受信データと周波数誤差補正部B3を乗算乗算器132、133へ入力して周波数補正を行い、セレクタ145、146を切り替えて平均化せずにそのまま出力する。なお、この時点で出力されるのは1シンボル当り64サンプルであり、ガードインターバルは除去されている。

【0033】

上記のようにして平均化されたロングリアンプルはFFT部220に入力され、時間軸方向のOFDM変調信号から周波数軸方向のサブキャリア信号に変換するマルチキャリア変調が行われる。サブキャリア信号に変換されたロングリアンプルは等化部230に入力され、伝送路応答推定部231で伝送路応答の推定と補正が行われる。

【0034】

図8に本実施例におけるFFT部220の構成例を示す。

本実施例のFFT部220は、周波数誤差推定補正部210からの入力を一時保持するためのメモリ221と、バタフライ演算を行う演算部222と、演算結果を保持するメモリ223およびメモリ224と、周波数誤差推定補正部210からの入力またはメモリ223に保持されている演算結果をバタフライ演算部222へ選択的に入力するためのセレクタ225と、符号変換と加算を行う加算部226とから構成されている。FFTにおけるバタフライ演算には、Radix2のバタフライ演算とRadix4のバタフライ演算が知られているが、本実施例においては、バタフライ演算部222はRadix4のバタフライ演算を行うように構成されている。Radix4のバタフライ演算は3つのステージ演算からなる。

【0035】

以下、64ポイントFFTによるRadix4のバタフライ演算 $x(n) \rightarrow X[k]$ ($n=0,1,\dots,63$; $k=0,1,\dots,63$)のアルゴリズムを説明する。

【0036】

【第1ステージ】

Radix4の第1ステージの演算を数式1に示す。本実施例のFFT部220では、この演算をバタフライ演算部222で行い、演算結果をメモリ223に格納する。

【0037】

【数1】

$$n = 16n_1 + n_2' \quad (n_1 = 0,1,2,3; n_2' = 0,1,\dots,15)$$

$$k = k_1 + 4k_2' \quad (k_1 = 0,1,2,3; k_2' = 0,1,2,\dots,15)$$

$$\begin{aligned} X[k] &= \sum_{n=0}^{63} x[n] W_{64}^{nk} \\ &= \sum_{n_2'=0}^{15} \sum_{n_1=0}^3 x[16n_1 + n_2'] W_{64}^{(16n_1+n_2')(k_1+4k_2')} \\ &= \sum_{n_2'=0}^{15} \sum_{n_1=0}^3 x[16n_1 + n_2'] W_{64}^{16n_1k_1} W_{64}^{64n_1k_2'} W_{64}^{n_2'k_1} W_{64}^{4n_2'k_2'} \\ &= \sum_{n_2'=0}^{15} \left(\sum_{n_1=0}^3 x[16n_1 + n_2'] W_4^{n_1k_1} W_{64}^{n_2'k_1} \right) W_{16}^{n_2'k_2'} \\ &= \sum_{n_2'=0}^{15} \tilde{x}_1[k_1, n_2'] W_{16}^{n_2'k_2'} \end{aligned}$$

$$W_N^{nk} = \exp\left(-\frac{2\pi nk}{N}\right) = \cos\left(\frac{2\pi nk}{N}\right) - j \cdot \sin\left(\frac{2\pi nk}{N}\right)$$

【0098】

【第2ステージ】

図14の第2ステージの演算を数式2に示す。本実施例のFFT部220では、この演算をメモリ229に格納されている値を読み出してセレクタ225を介してバタフライ演算部223へ入力させて行い、演算結果をメモリ224に格納する。

【0099】

【数2】

$$\begin{aligned}
n'_2 &= 4n_2 + n_3 \quad (n_2 = 0,1,2,3; n_3 = 0,1,2,3) \\
k'_2 &= k_2 + 4k_3 \quad (k_2 = 0,1,2,3; k_3 = 0,1,2,3) \\
&\sum_{n_2=0}^{15} \tilde{x}_1[k_1, n_2] W_{16}^{n_2 k'_2} \\
&= \sum_{n_1=0}^3 \sum_{n_2=0}^3 \tilde{x}_1[k_1, 4n_2 + n_3] W_{16}^{(4n_2 + n_3)(k_2 + 4k_3)} \\
&= \sum_{n_2=0}^3 \sum_{n_3=0}^3 \tilde{x}_1[k_1, 4n_2 + n_3] W_{16}^{4n_2 k_2} W_{16}^{16n_3 k_1} W_{16}^{n_3 k_2} W_{16}^{4n_3 k_3} \\
&= \sum_{n_1=0}^3 \left(\sum_{n_2=0}^3 \tilde{x}_1[k_1, 4n_2 + n_3] W_{16}^{n_2 k_2} W_{16}^{n_3 k_3} \right) W_4^{n_3 k_1} \\
&= \sum_{n_3=0}^3 \tilde{x}_2[k_1, k_2, n_3] W_4^{n_3 k_1}
\end{aligned}$$

【0040】

【第3ステージ】

図154の第3ステージの演算を数式3に示す。本実施例のFFT部220では、この演算を演算部226で行い、演算結果を出力する。

【0041】

【数3】

$$\sum_{n_3=0}^3 \tilde{x}_2[k_1, k_2, n_3] W_4^{n_3 k_1}$$

【0042】

上記アルゴリズムにおいて第3ステージに着目すると、数式3中の $W_4^{n_3 k_1}$ の項は数式4で表われ、数式4中の \cos 、 \sin の値として-1、0、1のいずれの値しか取らない。

【0043】

【数4】

$$W_4^{nk} = \exp\left(-\frac{2\pi nk}{4}\right) = \cos\left(\frac{2\pi nk}{4}\right) - j \cdot \sin\left(\frac{2\pi nk}{4}\right)$$

【0044】

従って、第3ステージの演算処理はそれぞれ符号反転、0、変換無し of いずれかで実現できるため、実質的に乗算処理が不要で、符号変換と加算処理のみで実行することができる。

るので、第1ステージ、第2ステージに比べ演算処理が軽くなる。そこで、本実施例のFDT部220では、演算部226を集算器に比べて回路規模が小さな加算器で構成するとともに、第3ステージの演算は第2ステージの演算と並列に行うようにしている。

【0045】

本実施例のFDT部220では、前記周波数誤差推定・補正部210にて周波数誤差補正された受信信号がメモリ221に格納され、第1ステージの演算に必要なデータが入力されるまで一時保持する。必要なデータが揃うと演算部222で第1ステージの演算（数式1）を行い、その結果をメモリ223に格納し、第1ステージの演算が完了するまで一時保持する。次に、セレクタ225を切り替えて第1ステージの演算結果を用いて演算部222で第2ステージの演算（数式2）を行い、その結果をメモリ224に格納する。この時、メモリ224には第3ステージの演算に必要な最小限の分だけ保持し、第2ステージの完了を待つことなく加算部226で第3ステージの演算（数式3）を行う。

【0046】

このようにすることで、図9（A）のタイミングチャートに示すように、第2ステージの演算処理と第3ステージの演算処理とを並列に行うことができる。図10にこの発明に先立って本発明者によって検討されたFDT部の構成例を示す。この発明に先立って本発明者によって検討されたFDT部は、メモリ224と加算部226がなく、上記第1～第3のステージの演算をすべて1つの演算部222により時分割で順に行うようになっていた。従って、この発明に先立って本発明者によって検討されたFDT部のタイミングチャートを示す図9（B）におけるデータ入力の開始からデータ出力の開始までのFDT処理時間と比較して、図9（A）に示す本実施例におけるデータ入力の開始からデータ出力までのFDT処理時間の方が、約1ステージ分だけ短縮される。

【0047】

また、第1ステージの演算を行う演算部と第2ステージの演算を行う演算部とを別個に設けることにより全ステージを並列できるように構成することもできるが、本実施例のように、第3ステージのみ並列処理化したことにより第2ステージの演算を行う演算部が不要となり、全ステージを並列化する場合に比べて回路規模の増加が抑えられる。前述したように、第3ステージの演算は総平均符号変動と加算処理で行えるので、本実施例のように第3ステージの演算を行う回路（加算器226）を追加したとしても回路規模の増加はわずかなもので済む。

【0048】

図10には、伝送路応答推定部231及び伝送路応答補正部232のブロック図を示す。伝送路応答推定部231では、ロングアリアンブルパターン生成部311により既知のロングアリアンブルの符号情報が生成されて符号正負変換部312へ供給され、受信ロングアリアンブルの符号をあわせることで伝送路応答の推定値が求められる。その後、各サブキャリア毎にパワー演算部313にて推定値の大きさ（推定値の2乗 $\cdot T$ ）を、また乗算・除算部314で推定値の逆数を求めることで伝送路応答補正値が算出され、補正データ保持用のメモリ321に格納される。次に、FDT部220にてサブキャリア信号に変換された、ロングアリアンブルの接続のシグナルシンボルS100LとデータシンボルDATAが、メモリ321に格納されている伝送路応答補正値を用いて乗算演算器322で復乗算され、伝送路応答の補正が行われる。

【0049】

上記処理を、図11（A）に示すタイミングチャートで説明する。なお、図11（A）のタイミングチャートでは、ショートアリアンブルについては図示を省略している。

【0050】

ロングアリアンブルT1、T2から周波数誤差を推定し、ロングアリアンブルの周波数誤差補正出力では周波数誤差補正されたアリアンブルT1'、T2'が同時に出力される。この後、平均化処理を行い、FDT出力ではノイズ低減されたロングアリアンブルT'がサブキャリア信号として出力される。従って、T'の出力と同時に伝送路応答の推定を開始することができ、続いてやってくるシグナルシンボルS100Lから伝送路応答補正を行

うことが可能となる。これによって、図3のような構成を有するこの発明に先立って本発明者によって検討された復調回路のタイミングチャートを示す図11 (B) と比較すると分かるように、受信パケットのデジタルシンボル51088Lの入力からデジタルシンボル51088Lの伝送路応答補正部までの遅延時間T_dが、図11 (A) に示すように1シンボル分だけ短くT_d'に短縮される。

【0051】

さて、ここでFFT処理前での平均化とFFT処理後での平均化が等価であることを示す。

2つの異なる時間において、同一期間をサンプリングした信号(サンプリング数Nを、 $x(n)=(x_0, x_1, x_2, \dots, x_{N-1})$ 、 $y(n)=(y_0, y_1, y_2, \dots, y_{N-1})$)とおき、それぞれの信号について離散フーリエ変換を行うと、次の数式5のようになる。

【0052】

【数5】

$$X(k_x) = \sum_{n=0}^{N-1} (x_{re}(n) + jx_{im}(n)) \left(\cos \frac{2\pi nk_x}{N} - j \sin \frac{2\pi nk_x}{N} \right)$$

$$Y(k_y) = \sum_{n=0}^{N-1} (y_{re}(n) + jy_{im}(n)) \left(\cos \frac{2\pi nk_y}{N} - j \sin \frac{2\pi nk_y}{N} \right)$$

【0053】

IEEE802.11a規格ではサンプリング周波数誤差が±2.0ppm以内であることが規定されており、平均化を行う2つの期間とは、時間的に同一シンボル(ロングリアンブル)内で連続していることを考慮すると、サンプリング周波数誤差については無視できるほど小さい。従って、 $k=k_x=k_y$ とみなすことができる。また、リアンブルでの伝送路応答の時間的変化は無視できるものとする。これらを周波数軸上で各サブキャリア毎に平均すると、数式6のようになる。

【0054】

【数6】

$$\frac{X(k) + Y(k)}{2} = \sum_{n=0}^{N-1} \left(\frac{x_{re}(n) + y_{re}(n)}{2} + j \frac{x_{im}(n) + y_{im}(n)}{2} \right) \left(\cos \frac{2\pi nk}{N} - j \sin \frac{2\pi nk}{N} \right)$$

【0055】

この数式は、時間軸上で各サンプルタイミング毎に平均した後に離散フーリエ変換したものを表した式と等価であり、上述した条件の下ではFFT処理前での平均化した場合とFFT処理後での平均化した場合とで違いは発生しないことが分かる。従って、本実施例のようにFFT処理の前でロングシンボルの平均化処理を行うことが可能である。

【0056】

(変形例)

実施例1(図4)の遅延素子からなる遅延部211は、RAM(ランダム・アクセス・メモリ)のようなメモリに置き換えることが可能である。かかる変形例では、ショートリアンブル1aを一時的にメモリに格納し、格納したショートリアンブル1aを、続いて入力されてくるショートリアンブル1bと共に周波数誤差推定部212に入力する。周波数誤差推定部212は実施例1と同様な構成を有しており、自己相関演算部121で

繰り返しパケーンの16サンプルの各サンプルから t_a と t_b の相関を取り、粗く周波数誤差の推定し、粗周波数誤差保持部122に格納する。

【0057】

次に、続いて入力されてくるロングアリアンブルT1を一時的にメモリに格納し、格納したロングアリアンブルT1を続いて入力されてくるロングアリアンブルT2と共に自己相関演算部121に入力し、64サンプルの各サンプルからT1とT2の相関を取り、先に推定した粗周波数誤差と合わせて周波数誤差演算部123で、より精密な周波数誤差推定を行い、推定値を出力する。それ以降の処理は実施例1と同様であるので、説明を省略する。

【0058】

この変形例の場合、入力される受信信号を遅延する遅延部の代わりに受信信号を記憶するメモリを用いた構成としているため、受信信号を一度格納すると任意のタイミングで読み出すことが可能となる。そのため、例えば前述のRFD部202において高速度ゲイン設定により適正レベルのショートアリアンブルがより長く得られるような場合、粗周波数誤差推定において、図6の遅延するショートアリアンブル t_a と t_b の自己相関を取る代わりに、 t_a とその2つ後のショートアリアンブル t_c による32サンプル間隔での自己相関を取ること、あるいは t_a と t_d による48サンプル間隔での自己相関を取ることとも可能となる。これによって、より精度の高い誤差推定が可能となる。

【0059】

これに対し、実施例1(図4)のように周波数誤差推定補正部210の入力部を遅延素子からなる遅延部211で構成すると、32サンプル間隔での自己相関を取る場合には、ショートアリアンブル t_a と t_b の2つのショートアリアンブル分遅延素子が必要となり、16サンプル間隔での自己相関を取る場合と比べて回路規模が増加するが、本変形例の場合はメモリへの読み込み・読み出しタイミングを制御することで、16サンプル間隔での自己相関を取る場合と比べて回路規模の増加を伴うことなくサンプル間隔の異なる相関を取ることができる。

【0060】

(実施例2)

本発明に係るOFDM復調回路の第2の実施例を図12に示す。この実施例は、周波数誤差推定補正部210に、周波数誤差推定を行う為にショートアリアンブル又はロングアリアンブルを保持する遅延部211とは別に、ロングアリアンブルの平均化処理を行う為に補正後のロングアリアンブルを遅延する遅延部215を設けたものである。周波数誤差推定値出力までは実施例1と同様であるので説明は省略する。周波数誤差推定部213は、図13のように構成される。実施例1における周波数誤差推定部213の構成を示す図7と比較すると明らかのように、この実施例では、複素乗算器が1つ少なく済む。

【0061】

また、実施例1では周波数誤差推定補正演算部131は64サンプル分先の周波数誤差を加味して周波数誤差補正値を求める必要があったが、本実施例ではその必要がなく、周波数誤差推定補正演算部131は最初のロングアリアンブル開始点を基準に各サンプルに対応した周波数誤差補正値A2を逐次出力すれば良い。そして、複素乗算器132にて上記補正値A2で周波数誤差補正された最初のロングアリアンブルT1' (遅延部215にて一時保持される。次に、2回目のロングアリアンブルT2を各サンプルに対し周波数誤差推定を行うと同時に、遅延部215に保持されている周波数誤差補正済みの最初のロングアリアンブルT1'の対応するサンプルを出力し、平均化部214にて補正後のアリアンブルT2'との平均化を行う。

【0062】

上記処理を、図14に示すタイミングチャートで説明する。なお、図14のタイミングチャートでは、ショートアリアンブルについては図示を省略している。

入力されたロングアリアンブルT1、T2に基づいて周波数誤差を推定し、ロングアリアンブルの周波数誤差推定出力では周波数誤差推定されたアリアンブルT1'、T2'が

順次に出力される。そして、 $T2'$ の出力と並行して平均化処理を行い、FFT出力ではノイズ低減されたロングプリアンブル T' がサブキャリア信号として出力される。この実施例では、FFTの出力 T' の精検と同時に伝送路伝答の推定を開始することができ、続いてやってくるシグナルシンボルSIRSIの発端から伝送路伝答補正を行うことが可能となる。

【0063】

(実施例3)

図15には本発明に係るOFDM復調回路の第3の実施例で用いられるFIR部の構成例を、図16にはそのFIR部を適用したOFDM復調回路を無線LANの復調部に使用した場合のシステム構成例を示す。

【0064】

本実施例におけるFIR部204は、図15に示すように、受信信号I用のフィルタ410と受信信号Q用のフィルタ420とからなり、各フィルタは、複数(m個)の遅延素子461a~461nが直列に接続された遅延段と、それぞれの遅延素子に付随して設けられ遅延された信号と所定の係数 $a1 \sim an$ とを掛け算する乗算器462a~462nからなる掛け算部と、各乗算器462a~462nの出力を加算する加算部470などからなる。さらに、この実施例のFIR部204においては、m番目の遅延素子461bとm+1番目の遅延素子461cとの間に、入力信号を遅延素子461aから461bまでを bypass せずに直接m+1番目の遅延素子461cに入力させるためのセレクタ481と、m+1番目以降の遅延素子461c~461nに対応した乗算器462c~462nに、係数 $a_{m+1} \sim a_n$ に代えて係数 $b_{m+1} \sim b_n$ を与えるセレクタ483c~483nが設けられている。なお、この発明に先立って本発明者によって検討されたFIRフィルタは、セレクタ481と483c~483nがなく、タップ数(段数)は固定で1つの係数 $a1 \sim a_n$ のみで動作する構成とされる。

【0065】

図16の実施例のシステムは、アンテナ部201で受信した信号がRF部202でベースバンド信号にダウンコンバートされて増幅され、受信信号I、Qと受信信号の強度を示すRSSI信号とがRF部202から出力される。出力された受信信号I、QとRSSI信号は、A/D変換部203内のA/D変換器301、302、303でデジタル信号に変換される。デジタル信号に変換されたRSSI信号は、パケット検出部501にて随時監視され、所定の判断基準を満たすかどうかでパケットを受信したか否かが決定される。パケット検出部501がパケットの受信を検出すると、その時のRSSI信号の値からAGC設定部502でRF部202内のAGC回路の大きなゲインが決定され、ゲイン設定制御信号がRF部202へ供給される。

【0066】

この実施例のシステムでは、受信開始の際にFIR部204は、図15に示されている受信信号I用フィルタ410、受信信号Q用フィルタ420のそれぞれのセレクタ481を制御して見かけ上の遅延段の段数を減らした状態に設定しておき、フィルタの入力から出力までの遅延時間を短縮するようにしている。そのため、RF部202にて増幅された受信信号I、QはA/D変換部203でデジタル変換され、FIR部204に入力され帯域外の高周波成分を除去されるが、FIR部204は遅延段の段数が少ない状態に設定されているため、遅延時間が短くされる。

【0067】

次に、受信パケットが検出されると、FIRフィルタから出力される受信信号に基づいて自動利得制御部205内の電力計算部503が受信電力を計算し、その値からRF部203内のAGC回路の精密なゲインを決定して設定を行う。この時AGCゲイン設定終了信号をFIR部204に伝達し、セレクタ481及び加算部470、係数選択用セレクタ483a~483nを通常動作に必要な性能となる段数と係数に切り替える。このようにすることで、パケット受信からAGCゲイン設定までの所要時間を短縮することが可能となる。

【0068】

図17(A)には本実施例のFIRフィルタを適用したシステムにおける処理のタイミングチャートが、図17(B)にはこの発明に先立って本発明者によって検討されたFIRフィルタを適用したシステムにおける処理のタイミングチャートが示されている。

【0069】

本実施例を適用したシステムでは、パケットを受信してからAGCのゲイン設定を行うまでの間、FIRフィルタは段数が少ない状態で動作するため、ショートアリアンブルは段数の多いこの発明に先立って本発明者によって検討されたFIRフィルタを適用したシステムに比べてAGCの粗設定までの時間が短縮されることが分かる。なお、その後、FIRフィルタの段数を通常動作に必要な状態に切り替えるため、AGC設定後のショートアリアンブルとロングアリアンブル、データは同一の遅延をもって出力される。従って、適正レベルの受信信号がより早く得られることになる。また、適正レベルのショートアリアンブルをより長く受信することができるようになるため、実施例2で述べた32サンプル間隔でのショートアリアンブルの自己相関による周波数誤差推定も容易となる。

【0070】

図18は、本発明に係るOFDM復調回路を、IEEE802.11a規格に準拠した無線LANシステムに適用した場合のシステム全体の構成例を示す。アンテナ201aまたは201bで受信された信号は、ダイバーシティ・送受信切り替えスイッチ601を通り、バンドパスフィルタ602で不要波が抑制されて、RF-IC204に入力される。RF-IC204でベースバンド信号に周波数変換されAGC回路で増幅された受信信号は、前記実施例のOFDM復調回路および変調回路を内蔵したベースバンドLSI610に入力され、A/D変換器611でデジタル信号に変換された後、ベースバンドプロセッサ612で復調処理が行われる。復調された信号は媒体アクセス制御部(Medium Access Control, MAC)613に入力され、プロトコルに則ったデータアクセス制御が行われ、I/Oインタフェース614を通して上位層とデータのやり取りが行われる。

【0071】

以上の実施例によれば、時間軸においてアリアンブルの平均化処理を行うことにより、周波数情報に変換するのは平均化されたアリアンブルとなるため、パケットが受信されてからベースバンド信号に変換された後、伝送路応答補正復調された信号が得られるまでの遅延時間を短縮することができる。

【0072】

また、パケット受信時の自動利得制御においてFIRフィルタを切り替えて段数を減らすことにより自動利得制御完了までの時間を短縮することができる。

【0073】

さらに、FFT処理におけるバタフライ演算の一部を並列に実行することにより、回路規模の増加を抑え、処理時間を短縮することができる。これらの結果、パケット受信から復調データ出力までの遅延時間を大幅に短縮することができる。

【0074】

送信時は上位層からI/Oインタフェース614を通してアクセス制御部613に送られプロトコルに則ったデータアクセス制御が行われ、ベースバンドプロセッサ612に送信データが送られる。ベースバンドプロセッサ612では送信データをOFDM信号に変調し、D/A変換器615でアナログ信号に変換した後、RF-IC204に入力され、RF-IC204で5GHz帯の信号に周波数変換され、送信用バンドパスフィルタ603で不要波を抑制した後、パワーアンプ604で送信信号を所望の信号強度まで電力増幅し、ダイバーシティ・送受信切り替えスイッチ601を通してアンテナ201aまたは201bから送信される。

【0075】

以上本発明者によってなされた発明を実施例に基づき具体的に説明したが、本発明は上記実施例に限定されるものではなく、その要旨を逸脱しない範囲で種々変更可能であることはいうまでもない。例えば前記実施例では、バタフライ演算としてfftを使用してい

るが、RxとTxを用いるようにしても良い。

【産業上の利用可能性】

【0076】

以上の説明では主として本発明者によってなされた発明をその背景となった利用分野であるIEEE802.11a規格の無線LANシステムにおけるOFDM復調回路に適用した場合を説明したが、本発明はそれに限定されるものでなく、OFDM変調方式を用いた無線通信システムにおける復調回路や放送システムにおける復調回路に利用することができる。

【図面の簡単な説明】

【0077】

【図1】この発明に先立って本発明者によって検討されたOFDM復調回路の構成例を示すブロック図である。

【図2】IEEE802.11a規格で規定されているパケットの構成を示す説明図である。

【図3】この発明に先立って本発明者によって検討されたOFDM復調回路における周波数誤差推定・補正部から等化部までの構成を示すブロック図である。

【図4】本発明に係るOFDM復調回路における周波数誤差推定・補正部から等化部までの構成を示すブロック図である。

【図5】実施例のOFDM復調回路における周波数誤差推定部の構成を示すブロック図である。

【図6】実施例のOFDM復調回路における周波数誤差推定のタイミングチャートである。

【図7】実施例のOFDM復調回路における周波数誤差補正部及び平均化部の構成を示すブロック図である。

【図8】実施例のOFDM復調回路におけるFFT部の構成を示すブロック図である。

【図9】(A)は実施例のOFDM復調回路のFFT部におけるタイミングチャート。(B)はこの発明に先立って本発明者によって検討されたOFDM復調回路のFFT部におけるタイミングチャートである。

【図10】実施例のOFDM復調回路における伝送路応答推定部及び伝送路応答補正部の構成を示すブロック図である。

【図11】(A)は実施例のOFDM復調回路におけるタイミングチャート。(B)はこの発明に先立って本発明者によって検討されたOFDM復調回路におけるタイミングチャートである。

【図12】OFDM復調回路の第2の実施例を示すブロック図である。

【図13】第2の実施例のOFDM復調回路における周波数誤差補正部及び平均化部及び遅延部の構成を示すブロック図である。

【図14】第2の実施例のOFDM復調回路におけるタイミングチャートである。

【図15】第3の実施例のOFDM復調回路におけるFIRフィルタ部の構成を示すブロック図である。

【図16】第3の実施例のOFDM復調回路の構成を示すブロック図である。

【図17】(A)は第3の実施例のOFDM復調回路におけるタイミングチャート。(B)はこの発明に先立って本発明者によって検討されたOFDM復調回路におけるタイミングチャートである。

【図18】本発明に係るOFDM復調回路を、IEEE802.11a規格に準拠した無線LANシステムに適用した場合のシステム全体の構成例を示すブロック図である。

【図19】この発明に先立って本発明者によって検討されたOFDM復調回路におけるFFT部の構成を示すブロック図である。

【図20】この発明に先立って本発明者によって検討されたOFDM復調回路におけるFIRフィルタ部の構成を示すブロック図である。

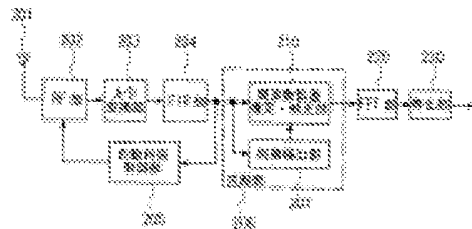
【符号の説明】

【0078】

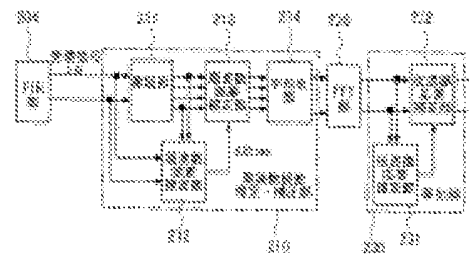
201 アンテナ

- 202 RF部
- 203 A/D変換部
- 204 FIR部
- 210 212 周波数誤差推定・補正部
- 211 遅延部
- 212 周波数誤差推定部
- 213 周波数誤差補正部
- 214 平均化部
- 220 FFT部
- 230 等化部
- 231 伝送遅延推定部
- 232 伝送遅延補正部
- 461 遅延素子
- 462 乗算器
- 470 加算部
- 481 段数切り替え用セレクタ
- 483 係数選択用セレクタ

【図1】



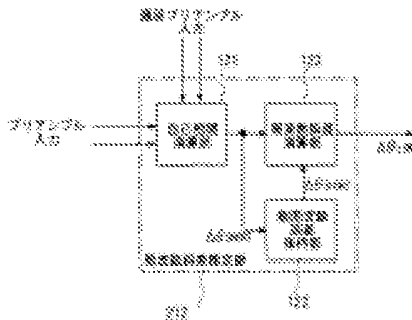
【図2】



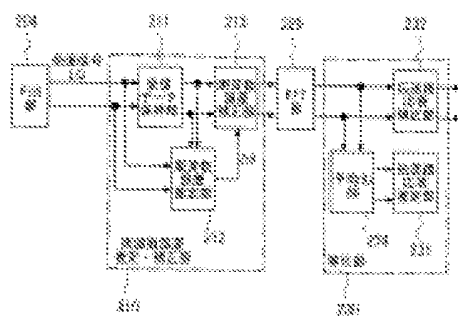
【図3】



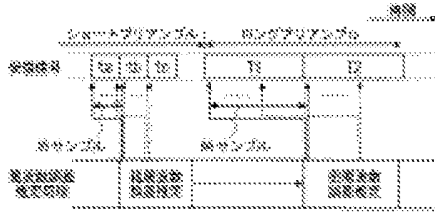
【図4】



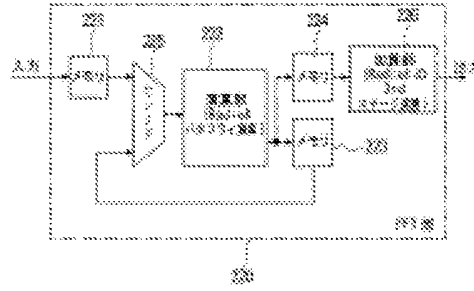
【図5】



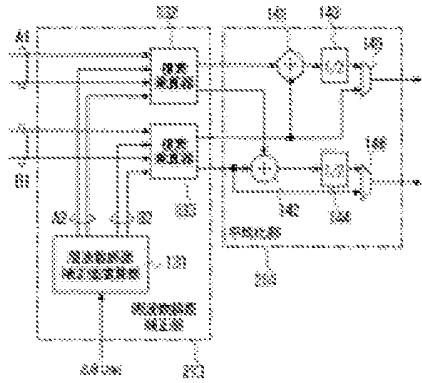
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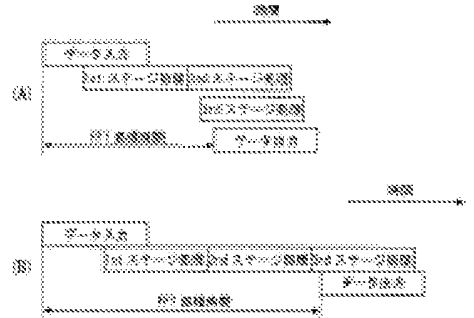
【139】



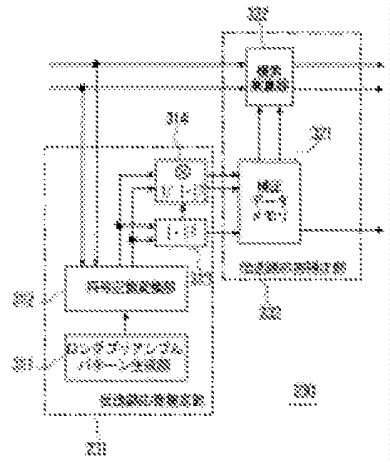
【139】



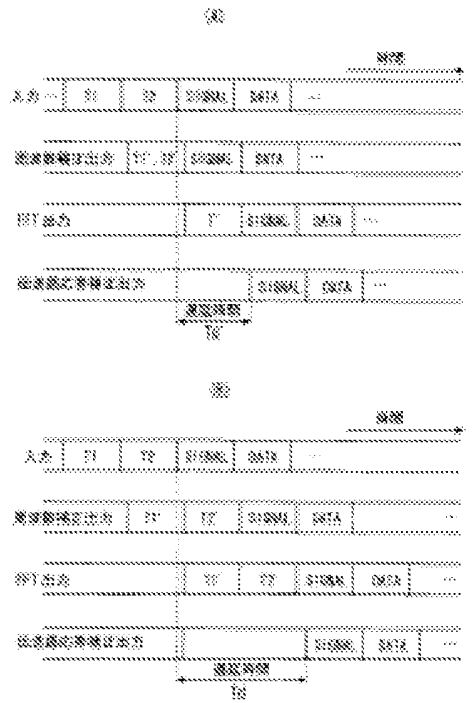
【139】



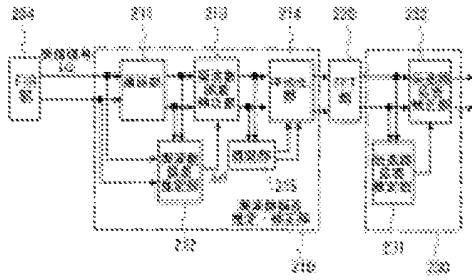
【139】



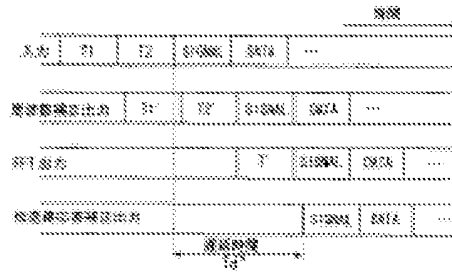
【139】



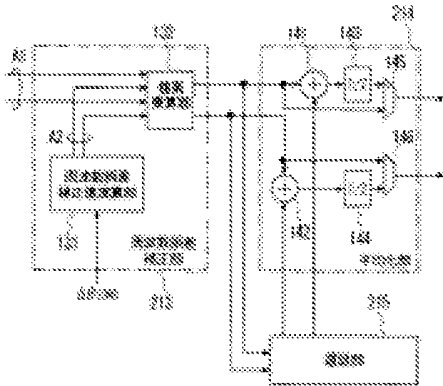
【図12】



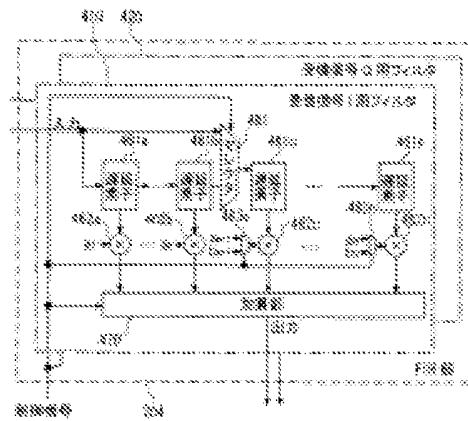
【図14】



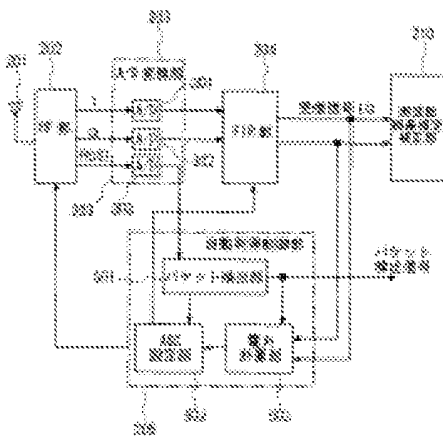
【図13】



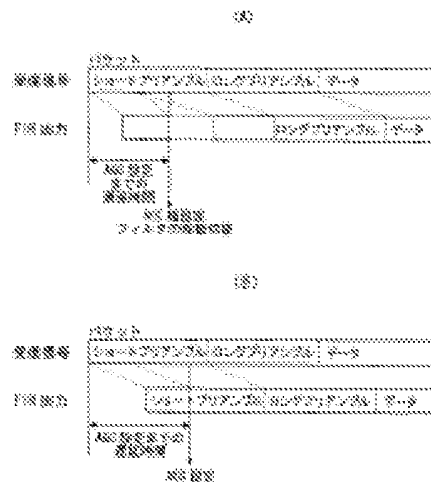
【図15】



【図16】



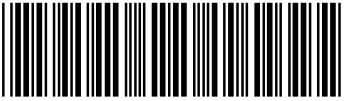
【図17】



(7) 発明者 高田 一幸

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Fターム(参考) 5K02 1001 1013 1019 1033

Index of Claims 	Application/Control No. 12303947	Applicant(s)/Patent Under Reexamination KWON ET AL.
	Examiner SHRIPAL KHAJURIA	Art Unit 2478

✓	Rejected
=	Allowed

-	Cancelled
÷	Restricted

N	Non-Elected
I	Interference

A	Appeal
O	Objected

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

CLAIM		DATE							
Final	Original	09/07/2011	02/24/2012						
1	31	✓	=						
2	32	✓	=						
3	33	✓	=						
4	34	✓	=						
5	35	✓	=						
6	36	✓	=						
7	37	✓	=						
8	38	✓	=						
9	39	✓	=						
10	40	✓	=						
11	41	✓	=						
12	42	✓	=						
13	43	✓	=						
14	44	✓	=						
15			=						
16			=						



NOTICE OF ALLOWANCE AND FEE(S) DUE

35884 7590 03/06/2012
LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

EXAMINER: KHAJURIA, SHRIPAL K
ART UNIT: 2478
PAPER NUMBER

DATE MAILED: 03/06/2012

Table with 5 columns: APPLICATION NO., FILING DATE, FIRST NAMED INVENTOR, ATTORNEY DOCKET NO., CONFIRMATION NO.

TITLE OF INVENTION: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

Table with 7 columns: APPLN. TYPE, SMALL ENTITY, ISSUE FEE DUE, PUBLICATION FEE DUE, PREV. PAID ISSUE FEE, TOTAL FEE(S) DUE, DATE DUE

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 SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

- A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.
B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

- A. Pay TOTAL FEE(S) DUE shown above, or
B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

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.

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**

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35884 7590 03/06/2012
LEE, HONG, DEGERMAN, KANG & WAIMEY
 660 S. FIGUEROA STREET
 Suite 2300
 LOS ANGELES, CA 90017

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 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.
12/303,947	07/07/2010	Yeong Hyeon Kwon	2101-3596	1730

TITLE OF INVENTION: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1740	\$300	\$0	\$2040	06/06/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
KHAJURIA, SHRIPAL K	2478	370-328000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363). <input type="checkbox"/> Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached. <input type="checkbox"/> "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, _____ 1 (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. _____ 2 _____ 3
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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: <input type="checkbox"/> Issue Fee <input type="checkbox"/> Publication Fee (No small entity discount permitted) <input type="checkbox"/> Advance Order - # of Copies _____	4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above) <input type="checkbox"/> A check is enclosed. <input type="checkbox"/> Payment by credit card. Form PTO-2038 is attached. <input type="checkbox"/> The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).
--	---

5. Change in Entity Status (from status indicated above)

a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

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Table with 5 columns: APPLICATION NO., FILING DATE, FIRST NAMED INVENTOR, ATTORNEY DOCKET NO., CONFIRMATION NO.
12/303,947 07/07/2010 Yeong Hyeon Kwon 2101-3596 1730

35884 7590 03/06/2012
LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

EXAMINER

KHAJURIA, SHRIPAL K

ART UNIT PAPER NUMBER

2478

DATE MAILED: 03/06/2012

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 5 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 5 day(s).

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 Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

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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.
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Notice of Allowability	Application No.	Applicant(s)	
	12/303,947	KWON ET AL.	
	Examiner	Art Unit	
	SHRIPAL KHAJURIA	2478	

-- 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 the amendment filed on 12/16/11.
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 31-46 (Renumbered 1-16).
4. Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 - 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. A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
 - (a) including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
 - 1) hereto or 2) to Paper No./Mail Date ____.
 - (b) 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).
7. 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)

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|---|---|
| 1. <input type="checkbox"/> Notice of References Cited (PTO-892) | 5. <input type="checkbox"/> Notice of Informal Patent Application |
| 2. <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 6. <input type="checkbox"/> Interview Summary (PTO-413),
Paper No./Mail Date ____. |
| 3. <input checked="" type="checkbox"/> Information Disclosure Statements (PTO/SB/08),
Paper No./Mail Date 10/31/11; 12/20/11; 12/21/11 | 7. <input type="checkbox"/> Examiner's Amendment/Comment |
| 4. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit
of Biological Material | 8. <input type="checkbox"/> Examiner's Statement of Reasons for Allowance |
| | 9. <input type="checkbox"/> Other ____. |

/S. K./
Examiner, Art Unit 2478

/J. P./
Supervisory Patent Examiner, Art Unit 2478

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Doc description: Information Disclosure Statement (IDS) Filed

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		12303947	
	Filing Date		2010-07-07	
	First Named Inventor	Yeong Hyeon Kwon		
	Art Unit	2478		
	Examiner Name	Khajuria, Shripal K.		
	Attorney Docket Number	2101-3596		

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/S.K./	1	2005260337	JP		2005-09-22	Renesas Tech Corp.		<input type="checkbox"/>
/S.K./	2	2004274794	JP		2004-09-30	Interdigital Tech Corp.		<input type="checkbox"/>
/S.K./	3	2004512728	JP		2004-04-22	Samsung Electronics Co., Ltd.		<input type="checkbox"/>

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		12303947	12303947 - GAU: 2478
	Filing Date		2010-07-07	
	First Named Inventor	Yeong Hyeon Kwon		
	Art Unit	2478		
	Examiner Name	Khajuria, Shripal K.		
	Attorney Docket Number	2101-3596		

/S.K./	4	04-035332	JP		1992-02-06	Sanyo Electric Co., Ltd.	<input type="checkbox"/>
/S.K./	5	11-154929	JP		1999-06-08	Nippon Telegraph & Telephone	<input type="checkbox"/>

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Search Notes 	Application/Control No. 12303947	Applicant(s)/Patent Under Reexamination KWON ET AL.
	Examiner SHRIPAL KHAJURIA	Art Unit 2478

SEARCHED			
Class	Subclass	Date	Examiner
370	328	9/7/2011	skk
370	328	2/24/2012	skk

SEARCH NOTES		
Search Notes	Date	Examiner
Text search of East (USPat, USPG_Pub, JPO, EPO, Derwent, IBM_TDB) and Inventor search	9/7/2011	skk
Updated Text search of East (USPat, USPG_Pub, JPO, EPO, Derwent, IBM_TDB)	2/24/2012	skk
Limited class search of 370/329 and 370/330	2/24/2012	skk
Consulted Jeff Pwu on allowable subject matter	2/24/2012	skk

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner
PgPub and UnPub	see attached search history	2/24/2012	skk

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
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L2	29796	han.in.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/02/24 22:58
L3	55702	park.in.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/02/24 22:58
L4	125629	kim.in.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/02/24 22:58
L5	195557	lee.in.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/02/24 22:58
L6	1930	noh.in.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/02/24 22:58
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S11	51	cyclic near prefix and preamble same repeat\$3 and CAZAC	US-PGPUB; USPAT; USOCR	OR	OFF	2011/09/07 10:52

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L9	14899	kwon.in.	US-PGPUB; USPAT; UPAD	OR	OFF	2012/02/24 22:59
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L18	26	cyclic near prefix and preamble and concatenating	USPAT; UPAD	OR	OFF	2012/02/24 23:03
L22	165	prefix and preamble and concatenating and length	US-PGPUB; USPAT; UPAD	OR	OFF	2012/02/24 23:03

2/ 24/ 2012 11:07:05 PM

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	Filing Date		2010-07-07	
	First Named Inventor	Yeong Hyeon Kwon		
	Art Unit	2478		
	Examiner Name	KHAJURIA, SHRIPAL K		
	Attorney Docket Number	2101-3596		

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	Filing Date		2010-07-07	
	First Named Inventor	Yeong Hyeon Kwon		
	Art Unit	2478		
	Examiner Name	KHAJURIA, SHRIPAL K		
	Attorney Docket Number	2101-3596		

/S.K./	1	CHANG ET AL: "Synchronization Method Based on a New Constant Envelop Preamble for OFDM Systems," IEEE TRANSACTIONS ON BROADCASTING, vol. 51, no. 1, March 2005, pp. 139-143, XP-011127926.	<input type="checkbox"/>
/S.K./	2	TEXAS INSTRUMENTS: "On Allocation of Uplink Pilot Sub-Channels in EUTRA SC-FDMA," R1-050822, 3GPP TSG-RAN WG1 Ad Hoc on LTE, August 2005, XP-002448008.	<input type="checkbox"/>

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	Filing Date		2010-07-07	
	First Named Inventor	Yeong Hyeon Kwon		
	Art Unit	2478		
	Examiner Name	KHAJURIA, SHRIPAL K		
	Attorney Docket Number	2101-3596		

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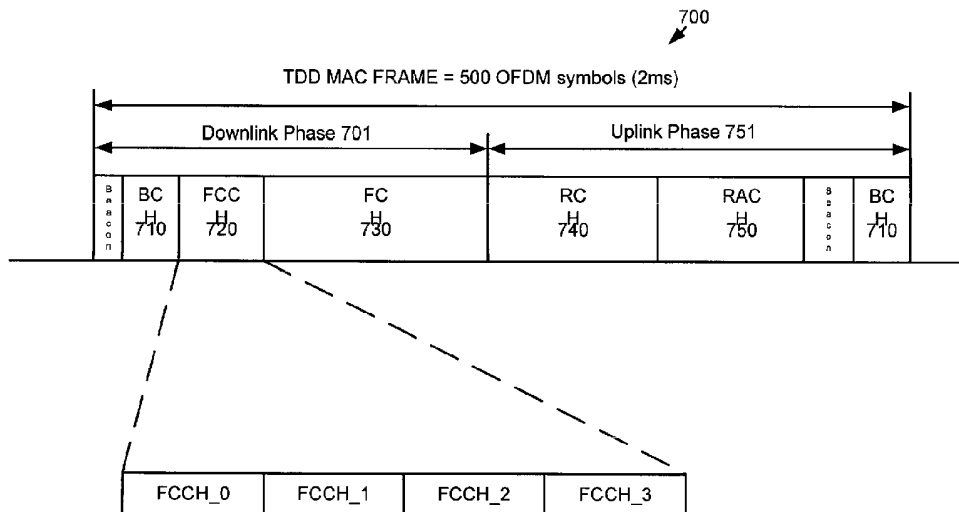
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[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR PROVIDING AN EFFICIENT CONTROL CHANNEL STRUCTURE IN A WIRELESS COMMUNICATION SYSTEM



(57) Abstract: According to one aspect of the invention, a method is provided in which a control channel used for transmitting control information is partitioned into a plurality of subchannels each of which is operated at a specific data rate. For each of one or more user terminals, one of the subchannels is selected based on one or more selection criteria for transmitting control information from an access point to the respective user terminal. Control information is transmitted from the access point to a user terminal on a particular subchannel selected for the respective user terminal. At the user terminal, one or more subchannels are decoded to obtain control information designated for the user terminal.

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METHOD AND APPARATUS FOR PROVIDING AN EFFICIENT CONTROL CHANNEL STRUCTURE IN A WIRELESS COMMUNICATION SYSTEM

BACKGROUND

I. Field

[0001] The present invention relates generally to data communication and processing, and more specifically to a method and apparatus for providing an efficient control channel structure in a wireless local area network (WLAN) communication system.

II. Background

[0002] Wireless communication systems have been widely deployed to provide various types of communication such as voice, packet data, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users sequentially or simultaneously by sharing the available system resources. Examples of multiple-access systems include Code Division Multiple Access (CDMA) systems, Time Division Multiple Access (TDMA) systems, and Frequency Division Multiple Access (FDMA) systems.

[0003] In recent years, wireless local area networks (WLANs) have also been widely deployed in accordance with various WLAN standards (e.g., IEEE 802.11a, 802.11b, and 802.11g, etc.) to enable communication among wireless electronic devices (e.g., computers) via wireless link. A WLAN may employ devices called access points (or base stations) that act like hubs and/or routers and provide connectivity for other wireless devices in the network (e.g. user terminals or user stations). The access points may also connect (or "bridge") the WLAN to wired LANs, thus allowing the wireless devices access to LAN resources.

[0004] In a wireless communication system, a radio frequency (RF) modulated signal from a transmitter unit may reach a receiver unit via a number of propagation paths. The characteristics of the propagation paths typically vary over time due to a number of factors, such as fading and multipath. To provide diversity against deleterious path effects and improve performance, multiple transmit and receive antennas may be used. If the propagation paths between the transmit and receive antennas are linearly

independent (e.g., a transmission on one path is not formed as a linear combination of the transmissions on the other paths), then the likelihood of correctly receiving a data transmission increases as the number of antennas increases. Generally, diversity increases and performance improves as the number of transmit and receive antennas increases.

[0005] A MIMO system employs multiple (N_T) transmit antennas and multiple (N_R) receive antennas for data transmission. A MIMO channel formed by the N_T transmit and N_R receive antennas may be decomposed into N_S spatial channels, with $N_S \leq \min\{N_T, N_R\}$. Each of the N_S spatial channels corresponds to a dimension. The MIMO system can provide improved performance (e.g., increased transmission capacity and/or greater reliability) if the additional dimensionalities created by the multiple transmit and receive antennas are utilized.

[0006] An exemplary MIMO WLAN system is described in the aforementioned U.S. Patent Application Serial No. 10/693,419, assigned to the assignee of the present invention. Such a MIMO WLAN system may be configured to provide various types of services and support various types of applications, and achieve a high level of system performance. In various embodiments, MIMO and orthogonal frequency division multiplexing (OFDM) may be employed to attain high throughput, combat deleterious path effects, and provide other benefits. Each access point in the system may be configured to support multiple user terminals. The allocation of downlink and uplink resources may be dependent on the requirements of the user terminals, the channel conditions, and other factors.

[0007] In one embodiment, the WLAN system as disclosed in the aforementioned U.S. Patent Application employs a channel structure designed to support efficient downlink and uplink transmissions. Such a channel structure may comprise a number of transport channels that may be used for various functions, such as signaling of system parameters and resource assignments, downlink and uplink data transmissions, random access of the system, and so on. Various attributes of these transport channels may be configurable, which allows the system to easily adapt to changing channel and loading conditions. One of these transport channels, called forward control channel (FCCH), may be used by the access point to allocate resources (e.g., channel assignments) on the downlink and uplink. The FCCH may also be used to provide acknowledgment for messages received on another transport channel.

[0008] As disclosed in the aforementioned U.S. Patent Application, in one embodiment, the FCCH can be transmitted or operable at different data rates (e.g., four different data rates). For example, the different data rates may include 0.25 bps/Hz, 0.5 bps/Hz, 1 bps/Hz, and 2 bps/Hz. However, in such a configuration, the rate employed on the FCCH is dictated by the worst case user in the system (i.e., the user that operates at the lowest data rate). This scheme is inefficient because a single user that cannot operate at a higher rate may reduce the efficiency and utilization of the FCCH, even though other users in the system may be able to operate at higher data rates.

[0009] There is, therefore, a need in the art for a method and apparatus to provide a more efficient control channel structure that is able to accommodate different users that may operate at different data rates.

SUMMARY

[0010] The various aspects and embodiments of the invention are described in further detail below. According to one aspect of the invention, a method is provided in which a control channel used for transmitting control information is partitioned into a plurality of subchannels each of which is operated at a specific data rate. For each of one or more user terminals, one of the subchannels is selected based on one or more selection criteria for transmitting control information from an access point to the respective user terminal. Control information is transmitted from the access point to a user terminal on a particular subchannel selected for the respective user terminal. At the user terminal, one or more subchannels are decoded to obtain control information designated for the user terminal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The various features and aspects of the invention can be understood from the detailed description set forth below in conjunction with the following drawings, in which:

[0012] FIG. 1 shows a block diagram of a MIMO WLAN system in which the teachings of the invention are implemented;

[0013] FIG. 2 shows a layer structure for the MIMO WLAN system;

[0014] FIG. 3 is a block diagram illustrating various components of an access point and user terminals;

- [0015] FIGS. 4A, 4B and 4C show a TDD-TDM frame structure, an FDD-TDM frame structure, and an FDD-CDM frame structure, respectively;
- [0016] FIG. 5 shows the TDD-TDM frame structure with five transport channels - BCH, FCCH, FCH, RCH, and RACH;
- [0017] FIGS. 6A and 6B illustrate various PDU formats for the various transport channels;
- [0018] FIG. 7 shows a new FCCH structure, in accordance with one embodiment of the invention;
- [0019] FIG. 8 shows a flow diagram of a method, in accordance with one embodiment of the invention; and
- [0020] FIG. 9 shows a flow diagram of a decoding process in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

- [0021] The word “exemplary” is used herein to mean “serving as an example, instance, or illustration.” Any embodiment or design described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other embodiments or designs.
- [0022] FIG. 1 shows a MIMO WLAN system 100 in which the teachings of the present invention are implemented. As shown in FIG. 1, MIMO WLAN system 100 includes a number of access points (APs) 110 that support communication for a number of user terminals (UTs) 120. For simplicity, only two access points 110 are shown in FIG. 1. An access point may also be referred to as a base station, access controller, or communication controller herein.
- [0023] User terminals 120 may be dispersed throughout the system. Each user terminal may be a fixed or mobile terminal that can communicate with the access point. A user terminal may also be referred to as a mobile station, a remote station, an access terminal, a user equipment (UE), a wireless device, or some other terminology herein. Each user terminal may communicate with one or possibly multiple access points on the downlink and/or uplink at any given moment. The downlink (also called forward link) refers to transmission from the access point to the user terminal, and the uplink (also called reverse link) refers to transmission from the user terminal to the access point.

[0024] In FIG. 1, access point 110a communicates with user terminals 120a through 120f, and access point 110b communicates with user terminals 120f through 120k. Depending on the specific design of system 100, an access point may communicate with multiple user terminals simultaneously (e.g., via multiple code channels or subbands) or sequentially (e.g., via multiple time slots). At any given moment, a user terminal may receive downlink transmissions from one or multiple access points. The downlink transmission from each access point may include overhead data intended to be received by multiple user terminals, user-specific data intended to be received by specific user terminals, other types of data, or any combination thereof. The overhead data may include pilot, page and broadcast messages, system parameters, and so on.

[0025] In one embodiment, the MIMO WLAN system is based on a centralized controller network architecture. Thus, a system controller 130 couples to access points 110 and may further couple to other systems and networks. For example, system controller 130 may couple to a packet data network (PDN), a wired local area network (LAN), a wide area network (WAN), the Internet, a public switched telephone network (PSTN), a cellular communication network, etc. System controller 130 may be designed to perform a number of functions such as (1) coordination and control for the access points coupled to it, (2) routing of data among these access points, (3) access and control of communication with the user terminals served by these access points, and so on. The MIMO WLAN system as shown in FIG. 1 may be operated in various frequency bands (e.g., the 2.4 GHz and 5.x GHz U-NII bands), subject to the bandwidth and emission constraints specific to the selected operating band.

[0026] In one embodiment, each access point may be equipped with multiple transmit and receive antennas (e.g., four transmit and receive antennas) for data transmission and reception. Each user terminal may be equipped with a single transmit/receive antenna or multiple transmit/receive antennas for data transmission and reception. The number of antennas employed by each user terminal type may be dependent on various factors such as, for example, the services to be supported by the user terminal (e.g., voice, data, or both), cost considerations, regulatory constraints, safety issues, and so on.

[0027] For a given pairing of multi-antenna access point and multi-antenna user terminal, a MIMO channel is formed by the N_T transmit antennas and N_R receive antennas available for use for data transmission. Different MIMO channels are formed between the access point and different multi-antenna user terminals. Each MIMO

channel may be decomposed into N_S spatial channels, with $N_S \leq \min \{N_T, N_R\}$. N_S data streams may be transmitted on the N_S spatial channels. Spatial processing is required at a receiver and may or may not be performed at a transmitter in order to transmit multiple data streams on the N_S spatial channels.

[0028] The N_S spatial channels may or may not be orthogonal to one another. This depends on various factors such as (1) whether or not spatial processing was performed at the transmitter to obtain orthogonal spatial channels and (2) whether or not the spatial processing at both the transmitter and the receiver was successful in orthogonalizing the spatial channels. If no spatial processing is performed at the transmitter, then the N_S spatial channels may be formed with N_S transmit antennas and are unlikely to be orthogonal to one another.

[0029] The N_S spatial channels may be orthogonalized by performing decomposition on a channel response matrix for the MIMO channel, as described in the aforementioned U.S. Patent Application. For a given number of (e.g., four) antennas at the access point, the number of spatial channels available for each user terminal is dependent on the number of antennas employed by that user terminal and the characteristics of the wireless MIMO channel that couples the access point antennas and the user terminal antennas. If a user terminal is equipped with one antenna, then the four antennas at the access point and the single antenna at the user terminal form a multiple-input single-output (MISO) channel for the downlink and a single-input multiple-output (SIMO) channel for the uplink.

[0030] The MIMO WLAN system as shown in FIG. 1 may be designed and configured to support various transmission modes, as illustrated in Table 1 below.

Table 1

Transmission modes	Description
SIMO	Data is transmitted from a single antenna but may be received by multiple antennas for receive diversity.
Diversity	Data is redundantly transmitted from multiple transmit antennas and/or multiple subbands to provide diversity.
Beam-steering	Data is transmitted on a single (best) spatial channel at full power using phase steering information for the principal eigenmode of the MIMO channel.

Spatial multiplexing	Data is transmitted on multiple spatial channels to achieve higher spectral efficiency.
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[0031] The transmission modes available for use for the downlink and uplink for each user terminal are dependent on the number of antennas employed at the user terminal. Table 2 lists the transmission modes available for different terminal types for the downlink and uplink, assuming multiple (e.g., four) antennas at the access point.

Table 2

Transmission modes	Downlink		Uplink	
	Single-antenna user terminal	Multi-antenna user terminal	Single-antenna user terminal	Multi-antenna user terminal
MISO (on downlink)/ SIMO (on uplink)	X	X	X	X
Diversity	X	X		X
Beam-steering	X	X		X
Spatial multiplexing		X		X

[0032] In an embodiment, the MIMO WLAN system employs OFDM to effectively partition the overall system bandwidth into a number of (N_F) orthogonal subbands. These subbands are also referred to as tones, bins, or frequency channels. With OFDM, each subband is associated with a respective subcarrier that may be modulated with data. For a MIMO system that utilizes OFDM, each spatial channel of each subband may be viewed as an independent transmission channel where the complex gain associated with each subband is effectively constant across the subband bandwidth.

[0033] In one embodiment, the system bandwidth can be partitioned into 64 orthogonal subbands (i.e., $N_F = 64$), which are assigned indices of -32 to $+31$. Of these 64 subbands, 48 subbands (e.g., with indices of $\pm\{1, \dots, 6, 8, \dots, 20, 22, \dots, 26\}$) can be used for data, 4 subbands (e.g., with indices of $\pm\{7, 21\}$) can be used for pilot and possibly signaling, the DC subband (with index of 0) is not used, and the remaining subbands are also not used and serve as guard subbands. This OFDM subband structure is described in further detail in a document for IEEE Standard 802.11a and entitled

“Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: High-speed Physical Layer in the 5 GHz Band,” September 1999, which is publicly available. In other embodiments, different numbers of subbands and various other OFDM subband structures may also be implemented for the MIMO WLAN system. For example, all 53 subbands with indices from -26 to +26 may be used for data transmission. As another example, a 128-subband structure, a 256-subband structure, or a subband structure with some other number of subbands may be used.

[0034] For OFDM, the data to be transmitted on each subband is first modulated (i.e., symbol mapped) using a particular modulation scheme selected for use for that subband. Zeros are provided for the unused subbands. For each symbol period, the modulation symbols and zeros for all N_F subbands are transformed to the time domain using an inverse fast Fourier transform (IFFT) to obtain a transformed symbol that contains N_F time-domain samples. The duration of each transformed symbol is inversely related to the bandwidth of each subband. In one specific design for the MIMO WLAN system, the system bandwidth is 20 MHz, $N_F = 64$, the bandwidth of each subband is 312.5 KHz, and the duration of each transformed symbol is 3.2 μ sec.

[0035] OFDM can provide certain advantages, such as the ability to combat frequency selective fading, which is characterized by different channel gains at different frequencies of the overall system bandwidth. It is well known that frequency selective fading causes inter-symbol interference (ISI), which is a phenomenon whereby each symbol in a received signal acts as distortion to subsequent symbols in the received signal. The ISI distortion degrades performance by impacting the ability to correctly detect the received symbols. Frequency selective fading can be conveniently combated with OFDM by repeating a portion of (or appending a cyclic prefix to) each transformed symbol to form a corresponding OFDM symbol, which is then transmitted.

[0036] The length of the cyclic prefix (i.e., the amount to repeat) for each OFDM symbol is dependent on the delay spread of the wireless channel. In particular, to effectively combat ISI, the cyclic prefix should be longer than the maximum expected delay spread for the system.

[0037] In an embodiment, cyclic prefixes of different lengths may be used for the OFDM symbols, depending on the expected delay spread. For the MIMO WLAN system described above, a cyclic prefix of 400 nsec (8 samples) or 800 nsec (16 samples) may be selected for use for the OFDM symbols. A “short” OFDM symbol

uses the 400 nsec cyclic prefix and has a duration of 3.6 μ sec. A “long” OFDM symbol uses the 800 nsec cyclic prefix and has a duration of 4.0 μ sec. Short OFDM symbols may be used if the maximum expected delay spread is 400 nsec or less, and long OFDM symbols may be used if the delay spread is greater than 400 nsec. Different cyclic prefixes may be selected for use for different transport channels, and the cyclic prefix may also be dynamically selectable, as described below. Higher system throughput may be achieved by using the shorter cyclic prefix when possible, since more OFDM symbols of shorter duration can be transmitted over a given fixed time interval.

[0038] FIG. 2 illustrates a layer structure 200 that may be used for the MIMO WLAN system. As shown in FIG. 2, in one embodiment, layer structure 200 includes (1) applications and upper layer protocols that approximately correspond to Layer 3 and higher of the ISO/OSI reference model (upper layers), (2) protocols and services that correspond to Layer 2 (the link layer), and (3) protocols and services that correspond to Layer 1 (the physical layer).

[0039] The upper layers includes various applications and protocols, such as signaling services 212, data services 214, voice services 216, circuit data applications, and so on. Signaling is typically provided as messages and data is typically provided as packets. The services and applications in the upper layers originate and terminate messages and packets according to the semantics and timing of the communication protocol between the access point and the user terminal. The upper layers utilize the services provided by Layer 2.

[0040] Layer 2 supports the delivery of messages and packets generated by the upper layers. In the embodiment shown in FIG. 2, Layer 2 includes a Link Access Control (LAC) sublayer 220 and a Medium Access Control (MAC) sublayer 230. The LAC sublayer implements a data link protocol that provides for the correct transport and delivery of messages generated by the upper layers. The LAC sublayer utilizes the services provided by the MAC sublayer and Layer 1. The MAC sublayer is responsible for transporting messages and packets using the services provided by Layer 1. The MAC sublayer controls the access to Layer 1 resources by the applications and services in the upper layers. The MAC sublayer may include a Radio Link Protocol (RLP) 232, which is a retransmission mechanism that may be used to provide higher reliability for packet data. Layer 2 provides protocol data units (PDUs) to Layer 1.

- [0041] Layer 1 comprises physical layer 240 and supports the transmission and reception of radio signals between the access point and user terminal. The physical layer performs coding, interleaving, modulation, and spatial processing for various transport channels used to send messages and packets generated by the upper layers. In this embodiment, the physical layer includes a multiplexing sublayer 242 that multiplexes processed PDUs for various transport channels into the proper frame format. Layer 1 provides data in units of frames.
- [0042] It should be understood by one skilled in the art that various other suitable layer structures may also be designed and used for the MIMO WLAN system.
- [0043] FIG. 3 shows a block diagram of one embodiment of an access point 110x and two user terminals 120x and 120y within the MIMO WLAN system.
- [0044] On the downlink, at access point 110x, a transmit (TX) data processor 310 receives traffic data (e.g., information bits) from a data source 308 and signaling and other information from a controller 330 and possibly a scheduler 334. These various types of data may be sent on different transport channels that are described in more details below. TX data processor 310 “frames” the data (if necessary), scrambles the framed/unframed data, encodes the scrambled data, interleaves (i.e., reorders) the coded data, and maps the interleaved data into modulation symbols. For simplicity, a “data symbol” refers to a modulation symbol for traffic data, and a “pilot symbol” refers to a modulation symbol for pilot. The scrambling randomizes the data bits. The encoding increases the reliability of the data transmission. The interleaving provides time, frequency, and/or spatial diversity for the code bits. The scrambling, coding, and modulation may be performed based on control signals provided by controller 330. TX data processor 310 provides a stream of modulation symbols for each spatial channel used for data transmission.
- [0045] A TX spatial processor 320 receives one or more modulation symbol streams from TX data processor 310 and performs spatial processing on the modulation symbols to provide four streams of transmit symbols, one stream for each transmit antenna.
- [0046] Each modulator (MOD) 322 receives and processes a respective transmit symbol stream to provide a corresponding stream of OFDM symbols. Each OFDM symbol stream is further processed to provide a corresponding downlink modulated signal. The four downlink modulated signals from modulator 322a through 322d are then transmitted from four antennas 324a through 324d, respectively.

- [0047] At each user terminal 120, one or multiple antennas 352 receive the transmitted downlink modulated signals, and each receive antenna provides a received signal to a respective demodulator (DEMOD) 354. Each demodulator 354 performs processing complementary to that performed at modulator 322 and provides received symbols. A receive (RX) spatial processor 360 then performs spatial processing on the received symbols from all demodulators 354 to provide recovered symbols, which are estimates of the modulation symbols sent by the access point.
- [0048] An RX data processor 370 receives and demultiplexes the recovered symbols into their respective transport channels. The recovered symbols for each transport channel may be symbol demapped, deinterleaved, decoded, and descrambled to provide decoded data for that transport channel. The decoded data for each transport channel may include recovered packet data, messages, signaling, and so on, which are provided to a data sink 372 for storage and/or a controller 380 for further processing.
- [0049] For the downlink, at each active user terminal 120, RX spatial processor 360 further estimates the downlink to obtain channel state information (CSI). The CSI may include channel response estimates, received SNRs, and so on. RX data processor 370 may also provide the status of each packet/frame received on the downlink. A controller 380 receives the channel state information and the packet/frame status and determines the feedback information to be sent back to the access point. The feedback information is processed by a TX data processor 390 and a TX spatial processor 392 (if present), conditioned by one or more modulators 354, and transmitted via one or more antennas 352 back to the access point.
- [0050] At access point 110, the transmitted uplink signal(s) are received by antennas 324, demodulated by demodulators 322, and processed by an RX spatial processor 340 and an RX data processor 342 in a complementary manner to that performed at the user terminal. The recovered feedback information is then provided to controller 330 and a scheduler 334.
- [0051] In one embodiment, scheduler 334 uses the feedback information to perform a number of functions such as (1) selecting a set of user terminals for data transmission on the downlink and uplink, (2) selecting the transmission rate(s) and the transmission mode for each selected user terminal, and (3) assigning the available FCH/RCH resources to the selected terminals. Scheduler 334 and/or controller 330 further uses

information (e.g., steering vectors) obtained from the uplink transmission for the processing of the downlink transmission.

[0052] As mentioned above, a number of services and applications may be supported by the MIMO WLAN system and various transport channels may be defined for the MIMO WLAN system to carry various types of data. Table 3 lists an exemplary set of transport channels and also provides a brief description for each transport channel.

Table 3

Transport channels		Description
Broadcast channel	BCH	Used by the access point to transmit pilot and system parameters to the user terminals.
Forward control channel	FCCH	Used by the access point to allocate resources on the downlink and uplink. The resource allocation may be performed on a frame-by-frame basis. Also used to provide acknowledgment for messages received on the RACH.
Forward channel	FCH	Used by the access point to transmit user-specific data to the user terminals and possibly a reference (pilot) used by the user terminals for channel estimation. May also be used in a broadcast mode to send page and broadcast messages to multiple user terminals.
Random access channel	RACH	Used by the user terminals to gain access to the system and send short messages to the access point.
Reverse channel	RCH	Used by the user terminals to transmit data to the access point. May also carry a reference used by the access point for channel estimation.

[0053] As shown in Table 3, the downlink transport channels used by the access point includes the BCH, FCCH, and FCH. The uplink transport channels used by the user terminals include the RACH and RCH. It should be recognized by one skilled in the art that the transport channels listed in Table 3 represent an exemplary embodiment of a channel structure that may be used for the MIMO WLAN system. Fewer, additional, and/or different transport channels may also be defined for use for the MIMO WLAN system. For example, certain functions may be supported by function-specific transport

channels (e.g., pilot, paging, power control, and sync channel channels). Thus, other channel structures with different sets of transport channels may be defined and used in the MIMO WLAN system, within the scope of the invention.

[0054] A number of frame structures may be defined for the transport channels. The specific frame structure to use for the MIMO WLAN system is dependent on various factors such as, for example, (1) whether the same or different frequency bands are used for the downlink and uplink and (2) the multiplexing scheme used to multiplex the transport channels together.

[0055] If only one frequency band is available, then the downlink and uplink may be transmitted on different phases of a frame using time division duplexing (TDD). If two frequency bands are available, then the downlink and uplink may be transmitted on different frequency bands using frequency division duplexing (FDD).

[0056] For both TDD and FDD, the transport channels may be multiplexed together using time division multiplexing (TDM), code division multiplexing (CDM), frequency division multiplexing (FDM), and so on. For TDM, each transport channel is assigned to a different portion of a frame. For CDM, the transport channels are transmitted concurrently but each transport channel is channelized by a different channelization code, similar to that performed in a code division multiple access (CDMA) system. For FDM, each transport channel is assigned a different portion of the frequency band on the link.

[0057] Table 4 lists the various frame structures that may be used to carry the transport channels. Each of these frame structures is described in further detail below.

Table 4

	Shared frequency band for downlink and uplink	Separate frequency bands for downlink and uplink
Time division	TDD-TDM frame structure	FDD-TDM frame structure
Code division	TDD-CDM frame structure	FDD-CDM frame structure

[0058] FIG. 4A illustrates an embodiment of a TDD-TDM frame structure 400a that may be used if a single frequency band is used for both the downlink and uplink. Data transmission occurs in units of TDD frames. Each TDD frame may be defined to span a particular time duration. The frame duration may be selected based on various factors such as, for example, (1) the bandwidth of the operating band, (2) the expected sizes

the PDUs for the transport channels, and so on. In general, a shorter frame duration may provide reduced delays. However, a longer frame duration may be more efficient since header and overhead may represent a smaller fraction of the frame. In one embodiment, each TDD frame has a duration of 2 msec.

[0059] As shown in FIG. 4A, each TDD frame can be partitioned into a downlink phase and an uplink phase. The downlink phase is further partitioned into three segments for the three downlink transport channels - the BCH, FCCH, and FCH. The uplink phase is further partitioned into two segments for the two uplink transport channels - the RCH and RACH.

[0060] The segment for each transport channel may be defined to have either a fixed duration or a variable duration that can change from frame to frame. In one embodiment, the BCH segment is defined to have a fixed duration, and the FCCH, FCH, RCH, and RACH segments are defined to have variable durations.

[0061] The segment for each transport channel may be used to carry one or more protocol data units (PDUs) for that transport channel. In the embodiment shown in FIG. 4A, a BCH PDU is transmitted in a first segment 410, an FCCH PDU is transmitted in a second segment 420, and one or more FCH PDUs are transmitted in a third segment 430 of the downlink phase. On the uplink phase, one or more RCH PDUs are transmitted in a fourth segment 440 and one or more RACH PDUs are transmitted in a fifth segment 450 of the TDD frame.

[0062] Frame structure 400a represents one arrangement of the various transport channels within a TDD frame. This arrangement can provide certain benefits such as reduced delays for data transmission on the downlink and uplink. The BCH is transmitted first in the TDD frame since it carries system parameters that may be used for the PDUs of the other transport channels within the same TDD frame. The FCCH is transmitted next since it carries resource allocation (e.g., channel assignment) information indicative of which user terminal(s) are designated to receive downlink data on the FCH and which user terminal(s) are designated to transmit uplink data on the RCH within the current TDD frame. Other TDD-TDM frame structures may also be defined and used for the MIMO WLAN system.

[0063] FIG. 4B illustrates an embodiment of an FDD-TDM frame structure 400b that may be used if the downlink and uplink are transmitted using two separate frequency bands. Downlink data is transmitted in a downlink frame 402a, and uplink data is

transmitted in an uplink frame 402b. Each downlink and uplink frame may be defined to span a particular time duration (e.g., 2 msec). For simplicity, the downlink and uplink frames may be defined to have the same duration and may further be defined to be aligned at the frame boundaries. However, different frame durations and/or non-aligned (i.e., offset) frame boundaries may also be used for the downlink and uplink.

[0064] As shown in FIG. 4B, the downlink frame is partitioned into three segments for the three downlink transport channels. The uplink frame is partitioned into two segments for the two uplink transport channels. The segment for each transport channel may be defined to have a fixed or variable duration, and may be used to carry one or more PDUs for that transport channel.

[0065] In the embodiment shown in FIG. 4B, the downlink frame carries a BCH PDU, an FCCH PDU, and one or more FCH PDUs in segments 410, 420, and 430, respectively. The uplink frame carries one or more RCH PDUs and one or more RACH PDUs in segments 440 and 450, respectively. This arrangement may provide the benefits described above (e.g., reduced delays for data transmission). Other FDD-TDM frame structures may also be defined and used for the MIMO WLAN system, and this is within the scope of the invention.

[0066] FIG. 4C illustrates an embodiment of an FDD-CDM/FDM frame structure 400c that may also be used if the downlink and uplink are transmitted using separate frequency bands. Downlink data may be transmitted in a downlink frame 404a, and uplink data may be transmitted in an uplink frame 404b. The downlink and uplink frames may be defined to have the same duration (e.g., 2 msec) and aligned at the frame boundaries.

[0067] As shown in FIG. 4C, the three downlink transport channels are transmitted concurrently in the downlink frame, and the two uplink transport channels are transmitted concurrently in the uplink frame. For CDM, the transport channels for each link are "channelized" with different channelization codes, which may be Walsh codes, orthogonal variable spreading factor (OVSF) codes, quasi-orthogonal functions (QOF), and so on. For FDM, the transport channels for each link are assigned different portions of the frequency band for the link. Different amounts of transmit power may also be used for different transport channels in each link.

[0068] Other frame structures may also be defined for the downlink and uplink transport channels, and this is within the scope of the invention. Moreover, it is possible

to use different types of frame structure for the downlink and uplink. For example, a TDM-based frame structure may be used for the downlink and a CDM-based frame structure may be used for the uplink.

[0069] In one embodiment, the transport channels as described above are used to send various types of data and may be categorized into two groups: common transport channels and dedicated transport channels.

[0070] The common transport channels, in one embodiment, may include the BCH, FCCH, and RACH. These transport channels are used to send data to or receive data from multiple user terminals. The BCH and FCCH can be transmitted by the access point using the diversity mode. On the uplink, the RACH can be transmitted by the user terminals using the beam-steering mode (if supported by the user terminal). The BCH can be operated at a known fixed rate so that the user terminals can receive and process the BCH without any additional information. As described in more details below, the FCCH support multiple rates to allow for greater efficiency. Each "rate" or "rate set" may be associated with a particular code rate (or coding scheme) and a particular modulation scheme.

[0071] The dedicated transport channels, in one embodiment, include the FCH and RCH. These transport channels are normally used to send user-specific data to or by specific user terminals. The FCH and RCH may be dynamically allocated to the user terminals as necessary and as available. The FCH may also be used in a broadcast mode to send overhead, page, and broadcast messages to the user terminals. In general, the overhead, page, and broadcast messages are transmitted prior to any user-specific data on the FCH.

[0072] FIG. 5 illustrates an exemplary transmission on the BCH, FCCH, FCH, RCH, and RACH based on TDD-TDM frame structure 400a. In this embodiment, one BCH PDU 510 and one FCCH PDU 520 are transmitted in BCH segment 410 and FCCH segment 420, respectively. FCH segment 430 may be used to send one or more FCH PDUs 530, each of which may be intended for a specific user terminal or multiple user terminals. Similarly, one or more RCH PDUs 540 may be sent by one or more user terminals in RCH segment 440. The start of each FCH/RCH PDU is indicated by an FCH/RCH offset from the end of the preceding segment. A number of RACH PDUs 550 may be sent in RACH segment 450 by a number of user terminals to access the system and/or to send short messages.

[0073] In one embodiment, the BCH is used by the access point to transmit a beacon pilot, a MIMO pilot, and system parameters to the user terminals. The beacon pilot is used by the user terminals to acquire system timing and frequency. The MIMO pilot is used by the user terminals to estimate the MIMO channel formed by the access point antennas and their own antennas. The system parameters specify various attributes of the downlink and uplink transmissions. For example, since the durations of the FCCH, FCH, RACH, and RCH segments are variable, the system parameters that specify the length of each of these segments for the current TDD frame are sent in the BCH.

[0074] FIG. 6A illustrates an embodiment of BCH PDU 410. In this embodiment, BCH PDU 410 includes a preamble portion 510 and a message portion 516. Preamble portion 510 further includes a beacon pilot portion 512 and a MIMO pilot portion 514. Portion 512 carries a beacon pilot and has a fixed duration of $T_{CP} = 8\mu\text{sec}$. Portion 514 carries a MIMO pilot and has a fixed duration of $T_{MP} = 32\mu\text{sec}$. Portion 516 carries a BCH message and has a fixed duration of $T_{BM} = 40\mu\text{sec}$. A preamble may be used to send one or more types of pilot and/or other information. A beacon pilot comprises a specific set of modulation symbols that is transmitted from all transmit antennas. A MIMO pilot comprises a specific set of modulation symbols that is transmitted from all transmit antennas with different orthogonal codes, which then allows the receivers to recover the pilot transmitted from each antenna. Different sets of modulation symbols may be used for the beacon and MIMO pilots.

[0075] In one embodiment, the BCH message carries system configuration information. Table 5 lists the various fields for an exemplary BCH message format.

Table 5 - BCH Message

Fields/ Parameter Names	Length (bits)	Description
Frame Counter	4	TDD frame counter
Net ID	10	Network identifier (ID)
AP ID	6	Access point ID
AP Tx Lvl	4	Access point transmit level
AP Rx Lvl	3	Access point receive level
FCCH Length	6	Duration of FCCH (in units of OFDM symbols)
FCCH Rate	2	Physical layer rate of FCCH

FCH Length	9	Duration of FCH (in units of OFDM symbols)
RCH Length	9	Duration of RCH (in units of OFDM symbols)
RACH Length	5	Duration of RACH (in units of RACH slots)
RACH Slot Size	2	Duration of each RACH slot (in units of OFDM symbols)
RACH Guard Interval	2	Guard interval at the end of RACH
Cyclic Prefix Duration	1	Cyclic prefix duration
Page Bit	1	"0" = page message sent on FCH "1" = no page message sent
Broadcast Bit	1	"0" = broadcast message sent on FCH "1" = no broadcast message sent
RACH Acknowledgment Bit	1	"0" = RACH acknowledgment sent on FCH "1" = no RACH acknowledgment sent
CRC	16	CRC value for the BCH message
Tail Bits	6	Tail bits for convolutional encoder
Reserved	32	Reserved for future use

[0076] The Frame Counter value may be used to synchronize various processes at the access point and user terminals (e.g., the pilot, scrambling codes, cover code, and so on). A frame counter may be implemented with a 4-bit counter that wraps around. This counter is incremented at the start of each TDD frame, and the counter value is included in the Frame Counter field. The Net ID field indicates the identifier (ID) of the network to which the access point belongs. The AP ID field indicates the ID of the access point within the network ID. The AP Tx Lvl and AP Rx Lvl fields indicate the maximum transmit power level and the desired receive power level at the access point, respectively. The desired receive power level may be used by the user terminal to determine the initial uplink transmit power.

[0077] The FCCH Length, FCH Length, and RCH Length fields indicate the lengths of the FCCH, FCH, and RCH segments, respectively, for the current TDD frame. In one embodiment, the lengths of these segments are given in units of OFDM symbols. The OFDM symbol duration for the BCH can be fixed at 4.0 μ sec. The OFDM symbol duration for all other transport channels (e.g., the FCCH, FCH, RACH, and RCH) is

variable and depends on the selected cyclic prefix, which is specified by the Cyclic Prefix Duration field. The FCCH Rate field indicates the rate used for the FCCH for the current TDD frame.

- [0078] The RACH Length field indicates the length of the RACH segment, which is given in units of RACH slots. The duration of each RACH slot is given by the RACH Slot Size field, in units of OFDM symbols. The RACH Guard Interval field indicates the amount of time between the last RACH slot and the start of the BCH segment for the next TDD frame.
- [0079] The Page Bit and Broadcast Bit indicate whether or not page messages and broadcast messages, respectively, are being sent on the FCH in the current TDD frame. These two bits may be set independently for each TDD frame. The RACH Acknowledgment Bit indicates whether or not acknowledgments for PDUs sent on the RACH in prior TDD frames are being sent on the FCCH in the current TDD frame.
- [0080] The CRC field includes a CRC value for the entire BCH message. This CRC value may be used by the user terminals to determine whether the received BCH message is decoded correctly or in error. The Tail Bits field includes a group of zeros used to reset the convolutional encoder to a known state at the end of the BCH message.
- [0081] As shown in Table 5, the BCH message includes a total of 120 bits. These 120 bits may be transmitted with 10 OFDM symbols. Table 5 shows one embodiment of the format for the BCH message. Other BCH message formats with fewer, additional, and/or different fields may also be defined and used, and this is within the scope of the invention.
- [0082] In one embodiment, the access point may allocate resources for the FCH and RCH on a per frame basis. The FCCH is used by the access point to convey the resource allocation information for the FCH and RCH (e.g., the channel assignments).
- [0083] FIG. 6B illustrates an embodiment of FCCH PDU 420. In this embodiment, the FCCH PDU includes only a portion 520 for an FCCH message. The FCCH message has a variable duration that can change from frame to frame, depending on the amount of scheduling information being carried on the FCCH for that frame. The FCCH message duration is in even number of OFDM symbols and given by the FCCH Length field on the BCH message. The duration of messages sent using the diversity mode (e.g., BCH and FCCH messages) is given in even number of OFDM symbols because the diversity mode transmits OFDM symbols in pairs.

[0084] In an embodiment, the FCCH can be transmitted using four possible rates. The specific rate used for the FCCH PDU in each TDD frame is indicated by the FCCH Phy Mode field in the BCH message. Each FCCH rate corresponds to a particular code rate and a particular modulation scheme and is further associated with a particular transmission mode.

[0085] An FCCH message may include zero, one, or multiple information elements (IEs). Each information element may be associated with a specific user terminal and may be used to provide information indicative of the assignment of FCH/RCH resources for that user terminal. Table 6 lists the various fields for an exemplary FCCH message format.

Table 6 - FCCH Message

Fields/ Parameter Names	Length (bits)	Description
N_IE	6	Number of IEs included in the FCCH message

N_IE information elements, each including:

IE Type	4	IE type
MAC ID	10	ID assigned to the user terminal
Control Fields	48 or 72	Control fields for channel assignment
Padding Bits	Variable	Pad bits to achieve even number of OFDM symbols in the FCCH message
CRC	16	CRC value for the FCCH message
Tail Bits	6	Tail bits for convolutional encoder

[0086] The N_IE field indicates the number of information elements included in the FCCH message sent in the current TDD frame. For each information element (IE) included in the FCCH message, the IE Type field indicates the particular type of this IE. Various IE types are defined for use to allocate resources for different types of transmissions, as described below.

[0087] The MAC ID field identifies the specific user terminal for which the information element is intended. Each user terminal registers with the access point at the start of a communication session and is assigned a unique MAC ID by the access point. This MAC ID is used to identify the user terminal during the session.

[0088] The Control Fields are used to convey channel assignment information for the user terminal and are described in detail below. The Padding Bits field includes a sufficient number of padding bits so that the overall length of the FCCH message is an even number of OFDM symbols. The FCCH CRC field includes a CRC value that may be used by the user terminals to determine whether the received FCCH message is decoded correctly or in error. The Tail Bits field includes zeros used to reset the convolutional encoder to a known state at the end of the FCCH message. Some of these fields are described in further detail below.

[0089] A number of transmission modes are supported by the MIMO WLAN system for the FCH and RCH, as indicated in Table 1. Moreover, a user terminal may be active or idle during a connection. Thus, a number of types of IE are defined for use to allocate FCH/RCH resources for different types of transmissions. Table 7 lists an exemplary set of IE types.

Table 7 - FCCH IE Types

IE Type	IE Size (bits)	IE Type	Description
0	48	Diversity Mode	Diversity mode only
1	72	Spatial Multiplexing Mode	Spatial multiplexing mode - variable rate services
2	48	Idle Mode	Idle state - variable rate services
3	48	RACH Acknowledgment	RACH acknowledgment - diversity mode
4		Beam Steering Mode	Beam steering mode
5-15	-	Reserved	Reserved for future use

[0090] For IE types 0, 1 and 4, resources are allocated to a specific user terminal for both the FCH and RCH (i.e., in channel pairs). For IE type 2, minimal resources are allocated to the user terminal on the FCH and RCH to maintain up-to-date estimate of the link. An exemplary format for each IE type is described below. In general, the rates and durations for the FCH and RCH can be independently assigned to the user terminals.

[0091] IE type 0 and 4 are used to allocate FCH/RCH resources for the diversity and beam-steering modes, respectively. For fixed low-rate services (e.g., voice), the rate

remains fixed for the duration of the call. For variable rate services, the rate may be selected independently for the FCH and RCH. The FCCH IE indicates the location of the FCH and RCH PDUs assigned to the user terminal. Table 8 lists the various fields of an exemplary IE Type 0 and 4 information element.

Table 8 - FCCH IE Type 0 and 4

Fields/ Parameter Names	Length (bits)	Description
IE Type	4	IE type
MAC ID	10	Temporary ID assigned to the user terminal
FCH Offset	9	FCH offset from start of the TDD frame (in OFDM symbols)
FCH Preamble Type	2	FCH preamble size (in OFDM symbols)
FCH Rate	4	Rate for the FCH
RCH Offset	9	RCH offset from start of the TDD frame (in OFDM symbols)
RCH Preamble Type	2	RCH preamble size (in OFDM symbols)
RCH Rate	4	Rate for the RCH
RCH Timing Adjustment	2	Timing adjustment parameter for RCH
RCH Power Control	2	Power control bits for RCH

[0092] The FCH and RCH Offset fields indicate the time offset from the beginning of the current TDD frame to the start of the FCH and RCH PDUs, respectively, assigned by the information element. The FCH and RCH Rate fields indicate the rates for the FCH and RCH, respectively.

[0093] The FCH and RCH Preamble Type fields indicate the size of the preamble in the FCH and RCH PDUs, respectively. Table 9 lists the values for the FCH and RCH Preamble Type fields and the associated preamble sizes.

[0094]

Table 9 - Preamble Type

Type	Bits	Preamble Size
0	00	0 OFDM symbol
1	01	1 OFDM symbol
2	10	4 OFDM symbols
3	11	8 OFDM symbols

[0095] The RCH Timing Adjustment field includes two bits used to adjust the timing of the uplink transmission from the user terminal identified by the MAC ID field. This timing adjustment is used to reduce interference in a TDD-based frame structure where the downlink and uplink transmissions are time division duplexed. Table 10 lists the values for the RCH Timing Adjustment field and the associated actions.

Table 10 - RCH Timing Adjustment

Bits	Description
00	Maintain current timing
01	Advance uplink transmit timing by 1 sample
10	Delay uplink transmit timing by 1 sample
11	Not used

[0096] The RCH Power Control field includes two bits used to adjust the transmit power of the uplink transmission from the identified user terminal. This power control is used to reduce interference on the uplink. Table 11 lists the values for the RCH Power Control field and the associated actions.

Table 11 - RCH Power Control

Bits	Description
00	Maintain current transmit power
01	Increase uplink transmit power by δ dB, where δ is a system parameter.
10	Decrease uplink transmit power by δ dB, where δ is a system parameter.
11	Not used

[0097] The channel assignment for the identified user terminal may be provided in various manners. In an embodiment, the user terminal is assigned FCH/RCH resources for only the current TDD frame. In another embodiment, the FCH/RCH resources are assigned to the terminal for each TDD frame until canceled. In yet another embodiment, the FCH/RCH resources are assigned to the user terminal for every n -th TDD frame, which is referred to as “decimated” scheduling of TDD frames. The different types of assignment may be indicated by an Assignment Type field in the FCCH information element.

[0098] IE type 1 is used to allocate FCH/RCH resources to user terminals using the spatial multiplexing mode. The rate for these user terminals is variable, and may be selected independently for the FCH and RCH. Table 12 lists the various fields of an exemplary IE type 1 information element.

Table 12 - FCCH IE Type 1

Fields/ Parameter Names	Length (bits)	Description
IE Type	4	IE type
MAC ID	10	Temporary ID assigned to the user terminal
FCH Offset	9	FCH offset from end of FCCH (in OFDM symbols)
FCH Preamble Type	2	FCH preamble size (in OFDM symbols)
FCH Spatial Channel 1 Rate	4	Rate for the FCH for spatial channel 1
FCH Spatial Channel 2 Rate	4	Rate for the FCH for spatial channel 2
FCH Spatial Channel 3 Rate	4	Rate for the FCH for spatial channel 3
FCH Spatial Channel 4 Rate	4	Rate for the FCH for spatial channel 4
RCH Offset	9	RCH offset from end of FCH (in OFDM symbols)
RCH Preamble Type	2	RCH preamble size (in OFDM symbols)
RCH Spatial Channel 1 Rate	4	Rate for the RCH for spatial channel 1
RCH Spatial Channel 2 Rate	4	Rate for the RCH for spatial channel 2
RCH Spatial Channel 3 Rate	4	Rate for the RCH for spatial channel 3
RCH Spatial Channel 4 Rate	4	Rate for the RCH for spatial channel 4

RCH Timing Adjustment	2	Timing adjustment parameter for RCH
Reserved	2	Reserved for future use

[0099] For IE type 1, the rate for each spatial channel may be selected independently on the FCH and RCH. The interpretation of the rates for the spatial multiplexing mode is general in that it can specify the rate per spatial channel (e.g., for up to four spatial channels for the embodiment shown in Table 12). The rate is given per eigenmode if the transmitter performs spatial processing to transmit data on the eigenmodes. The rate is given per antenna if the transmitter simply transmits data from the transmit antennas and the receiver performs the spatial processing to isolate and recover the data (for the non-steered spatial multiplexing mode).

[00100] The information element includes the rates for all enabled spatial channels and zeros for the ones not enabled. User terminals with less than four transmit antennas set the unused FCH/RCH Spatial Channel Rate fields to zero. Since the access point is equipped with four transmit/receive antennas, user terminals with more than four transmit antennas may use them to transmit up to four independent data streams.

[00101] IE type 2 is used to provide control information for user terminals operating in an *Idle* state. In an embodiment, when a user terminal is in the *Idle* state, steering vectors used by the access point and user terminal for spatial processing are continually updated so that data transmission can start quickly if and when resumed. Table 13 lists the various fields of an exemplary IE type 2 information element.

Table 13 - FCCH IE Type 2

Fields/ Parameter Names	Length (bits)	Description
IE Type	4	IE type
MAC ID	10	Temporary ID assigned to the user terminal
FCH Offset	9	FCH offset from end of FCCH (in OFDM symbols)
FCH Preamble Type	2	FCH preamble size (in OFDM symbols)
RCH Offset	9	RCH offset from end of FCH (in OFDM symbols)
RCH Preamble Type	2	RCH preamble size (in OFDM symbols)
Reserved	12	Reserved for future use

[00102] IE type 3 is used to provide quick acknowledgment for user terminals attempting to access the system via the RACH. To gain access to the system or to send a short message to the access point, a user terminal may transmit an RACH PDU on the uplink. After the user terminal sends the RACH PDU, it monitors the BCH to determine if the RACH Acknowledgement Bit is set. This bit is set by the access point if any user terminal was successful in accessing the system and an acknowledgment is being sent for at least one user terminal on the FCCH. If this bit is set, then the user terminal processes the FCCH for acknowledgment sent on the FCCH. IE Type 3 information elements are sent if the access point desires to acknowledge that it correctly decoded the RACH PDUs from the user terminals without assigning resources. Table 14 lists the various fields of an exemplary IE Type 3 information element.

Table 14 - FCCH IE Type 3

Fields/ Parameter Names	Length (bits)	Description
IE Type	4	IE type
MAC ID	10	Temporary ID assigned to user terminal
Reserved	34	Reserved for future use

[00103] A single or multiple types of acknowledgment may be defined and sent on the FCCH. For example, a quick acknowledgment and an assignment-based acknowledgment may be defined. A quick acknowledgment may be used to simply acknowledge that the RACH PDU has been received by the access point but that no FCH/RCH resources have been assigned to the user terminal. An assignment-based acknowledgment includes assignments for the FCH and/or RCH for the current TDD frame.

[00104] A number of different rates are supported for the transport channels. Each rate is associated with a particular code rate and a particular modulation scheme, which collectively results in a particular spectral efficiency (or data rate). Table 15 lists the various rates supported by the system.

Table 15

Rate Word	Spectral Efficiency	Code Rate	Modulation Scheme	Info bits/ OFDM	Code bits/ OFDM

	(bps/Hz)			symbol	symbol
0000	0.0	-	off	-	-
0001	0.25	$\frac{1}{4}$	BPSK	12	48
0010	0.5	$\frac{1}{2}$	BPSK	24	48
0011	1.0	$\frac{1}{2}$	QPSK	48	96
0100	1.5	$\frac{3}{4}$	QPSK	72	96
0101	2.0	$\frac{1}{2}$	16 QAM	96	192
0110	2.5	$\frac{5}{8}$	16 QAM	120	192
0111	3.0	$\frac{3}{4}$	16 QAM	144	192
1000	3.5	$\frac{7}{12}$	64 QAM	168	288
1001	4.0	$\frac{2}{3}$	64 QAM	192	288
1010	4.5	$\frac{3}{4}$	64 QAM	216	288
1011	5.0	$\frac{5}{6}$	64 QAM	240	288
1100	5.5	$\frac{11}{16}$	256 QAM	264	384
1101	6.0	$\frac{3}{4}$	256 QAM	288	384
1110	6.5	$\frac{13}{16}$	256 QAM	312	384
1111	7.0	$\frac{7}{8}$	256 QAM	336	384

[00105] While the FCCH channel structure as described above can be operable at different data rates, this structure may not be efficient because the rate employed on the FCCH is dictated or limited by the worst-case user in the system (e.g., the user that operates at the lowest data rate). For example, if one of the users can only receive and decode information on the FCCH at a low data rate of 0.25 bps/Hz, other users in the system will be adversely affected even though they are capable of operating at higher data rates. This is because the rate employed on the FCCH structure will be limited to that of the worst-case user, which is 0.25 bps/Hz. Thus, the FCCH performance and efficiency may be reduced by a single user. As described in more details below, the present invention provides a novel and more efficient FCCH channel structure that can be used to accommodate different users operable at different data rates.

[00106] In one embodiment, the new FCCH structure, also referred to as a tiered control channel structure or segregated control channel structure herein), comprises multiple control channels (e.g., 4 distinct control channels). Each of these distinct control

channels, also called control subchannel or FCCH subchannel herein, can operate at one of the multiple overhead data rates (e.g., one or four different data rates as mentioned above).

[00107] FIG. 7 illustrates a diagram of a new FCCH structure within a TDD MAC frame, in accordance with one embodiment of the invention. It should be understood by one skilled in the art that while TDD-TDM frame structure is used in this example for the purposes of illustration and explanation, the teachings of the present invention are not limited to TDD frame structure but can also be applied to various other frame structures of various durations (e.g., FDD-TDM, etc). As shown in FIG. 7, the TDD MAC frame is partitioned into a downlink phase (also called downlink segment) 701 and an uplink phase (also called uplink segment) 751. In this embodiment, the downlink phase is further divided into three segments for the three corresponding transport channels – the BCH 710, the FCCH 720, and the FCH 730. The uplink phase is further partitioned into two segments for the two corresponding transport channels – the RCH 740 and the RACH 750.

[00108] As shown in FIG. 7, the FCCH segment is divided or partitioned into multiple distinct FCCH segments or subchannels, each of which may operate at a specific data rate. In this example, the FCCH segment is divided into four FCCH subchannels (FCCH_0, FCCH_1, FCCH_2, and FCCH_3). In other embodiments of the invention, the FCCH segment may be divided into different numbers of subchannels (e.g., 8 subchannels, etc.), depending on the particular applications or implementations of the invention. In one embodiment, each FCCH subchannel may be associated with a specific set of operating and processing parameters (e.g., code rate, modulation scheme, SNR, etc.). For example, Table 16 below illustrates the code rates, modulation scheme, SNR, etc., that are associated with each FCCH subchannel. In this example, STTD is employed for each of the subchannels, in which case the length of each subchannel is a multiple of two OFDM symbols.

Table 16 – FCCH Subchannel Data Rates (STTD)

FCCH Subchannel	Efficiency (bps/Hz)	Code Rate	Modulation	Information Bits Per STTD OFDM	Total SNR for 1% Frame Error Rate (FER)

				symbol	
FCCH_0	0.25	0.25	BPSK	24	-2.0 dB
FCCH_1	0.5	0.5	BPSK	48	2.0 dB
FCCH_2	1	0.5	QPSK	96	5.0 dB
FCCH_3	2	0.5	16 QAM	192	11.0 dB

[00109] As shown in Table 16, each FCCH subchannel has a distinct operating point (e.g., SNR and other processing parameters) associated with it. A user terminal (UT) that is assigned a specific FCCH subchannel (e.g., FCCH_n at a particular rate) can correctly decode all lower rate subchannels, but not those operating at the higher rates. For example, if a particular user terminal is assigned subchannel FCCH_2, that user terminal can decode FCCH_0 and FCCH_1 subchannels because FCCH_0 and FCCH_1 operate at the lower rates. However, that user terminal cannot decode FCCH_3 because FCCH_3 operates at a higher rate. In one embodiment, the access point (AP) decides which FCCH subchannel to send control data to a UT based on various factors or selection criteria. These various factors or selection may include link quality information or operating conditions of the user terminals (e.g., C/I, Doppler, etc.), quality of service (QoS) requirements associated with the user terminals, and control subchannel preference indicated by the user terminals, etc. As described in more details below, the user terminals then attempt to decode each of the FCCH subchannels to determine if they have been allocated resources (e.g., FCH/RCH channel resources).

[00110] Table 17 illustrates the structure for the various FCCH subchannels, in accordance with one embodiment of the present invention. As shown in Table 17, the FCCH subchannel structure for subchannel FCCH_0 is distinct from the structure used for other FCCH subchannels (FCCH_1, FCCH_2, and FCCH_3). In one embodiment, the FCCH_MASK field in the FCCH_0 structure is used to indicate the presence/absence of higher rate FCCH subchannels in a particular order. For example, the FCCH_MASK field may comprise three bits each of which corresponds to a particular subchannel and is used to indicate whether the particular subchannel is present in an order from subchannel 1 (MASK bit 0), subchannel 2 (MASK bit 1), and subchannel 3 (MASK bit 2). The corresponding subchannel MASK bit is set to a particular value (e.g., 1) to indicate the presence of the respective subchannel. For example, if the value of MASK bit number 0 (the least significant MASK bit) is set to

“1”, this indicates the presence of FCCH_1 subchannel. Pad bits are provided to achieve an even number of OFDM symbols in each subchannel. In one embodiment, each FCCH subchannel is capable of providing scheduling information for multiple user terminals (e.g., 32 users). The IE types described above can be used for the FCCH subchannels.

Table 17 – FCCH Subchannel Structure

FCCH_0:	Bits
FCCH MASK	3
No. IE Rate 0	5
Rate 0 IE's	
0 Padding	
CRC	16
Tail	6
FCCH_1:	Bits
No. IE Rate 1	5
Rate 1 IE's	
0 Padding	
CRC	16
Tail	6
FCCH_2:	Bits
No. IE Rate 2	5
Rate 2 IE's	
0 Padding	
CRC	16
Tail	6
FCCH_3:	Bits
No. IE Rate 3	5
Rate 3 IE's	
0 Padding	
CRC	16
Tail	6

[00111] FIG.8 illustrates a flow diagram of a method 800 in accordance with one embodiment of the present invention. At block 810, as described above, a control channel is segregated or partitioned into a plurality of subchannels each of which being operable at a specific data rate. At block 820, control information including resource allocation information is transmitted from an access point to a user terminal on a particular subchannel of the plurality subchannels selected for the user terminal, based on one or more selection criteria, as described above. At block 830, at the user terminal, one or more subchannels of the plurality of subchannels are decoded to obtain control information (e.g., channel assignments) designated for the user terminal. In one embodiment, as explained in more details below, the decoding procedure performed at the user terminal starts with the FCCH subchannel operated at the lowest data rate (FCCH_0 in this example) and continues until at least one of a plurality of conditions is satisfied.

[00112] FIG. 9 shows a flow diagram of a decoding procedure 900 performed by a user terminal in decoding the new FCCH structure, in accordance with one embodiment of the present invention. The user terminal starts by decoding the subchannel FCCH_0. In one embodiment, decoding is considered successful if the CRC test passes. The user terminal terminates FCCH decoding process whenever any of the following events occurs:

- (i) Failure to correctly decode an FCCH subchannel;
- (ii) Receipt of an assignment;
- (iii) Decoding of all active FCCH subchannels without receiving an assignment.

[00113] Referring again to FIG. 9, at block 910, the process begins by initializing n to 0. In this example, n is a variable used to indicate the current FCCH subchannel being decoded in the current iteration of the process. At block 915, the current FCCH _{n} subchannel is decoded. For example, in the first iteration, FCCH_0 is decoded at block 915. At block 920, it is determined whether the CRC test with respect to the current FCCH _{n} subchannel passes. If the CRC test passes, the process proceeds to block 925 to determine whether the corresponding MAC ID is present, otherwise the process proceeds to block 930 to process the next MAC frame. At block 925, if the corresponding MAC ID is present, the process proceeds to block 940 to obtain the assignment information provided by the access point. Otherwise, the process proceeds to block 935 to check if n is equal to 3. At block 935, if n is equal to 3, the process

proceeds to block 945 to initialize the FCCH_MASK field to indicate that all FCCH subchannels have been processed. As described above, in one embodiment, the FCCH_MASK field in the FCCH_0 subchannel structure comprises three bits each of which is used to indicate the presence/absence of a corresponding higher rate FCCH subchannel. For example, the first bit (bit 0 or the least significant bit) of the FCCH_MASK field is used to indicate the presence/absence of subchannel 1, the second bit (bit 1 or the next significant bit) of the FCCH_MASK field is used to indicate the presence/absence of subchannel 2, and so on. The process then proceeds to block 950 to determine whether there are any active FCCH subchannels remaining to be decoded. If there are more active FCCH subchannels to be decoded, the process proceeds to block 960 to increment n to the next active FCCH subchannel. Otherwise the process proceeds to block 955 to process the next MAC frame.

[00114] Various parts of the MIMO WLAN system and various techniques described herein may be implemented by various means. For example, the processing at the access point and user terminal may be implemented in hardware, software, or a combination thereof. For a hardware implementation, the processing may be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described herein, or a combination thereof.

[00115] For a software implementation, the processing may be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in a memory unit and executed by a processor. The memory unit may be implemented within the processor or external to the processor, in which case it can be communicatively coupled to the processor via various means as is known in the art.

[00116] Headings are included herein for reference and to aid in locating certain sections. These headings are not intended to limit the scope of the concepts described therein under, and these concepts may have applicability in other sections throughout the entire specification.

[00117] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to

these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

WHAT IS CLAIMED IS:

CLAIMS

1. A method for processing information in a communication system, comprising:
partitioning a control channel used for transmitting control information into a plurality of subchannels, each subchannel being operated at a specific data rate;
selecting, for each of one or more user terminals, one of the subchannels to be used for transmitting control information from an access point to the respective user terminal, based on one or more selection criteria; and
transmitting control information from the access point to a particular user terminal on a particular subchannel selected for the respective user terminal.
2. The method of claim 1 wherein the control information is transmitted in a segment of a data frame specifically allocated for the control channel.
3. The method of claim 1 wherein each subchannel is associated with a specific set of operating parameters.
4. The method of claim 3 wherein the operating parameters are selected from the group consisting of a code rate, a modulation scheme, and a signal-to-noise ratio (SNR).
5. The method of claim 1 wherein the plurality of subchannels are transmitted sequentially in an order from a subchannel with a lowest data rate to a subchannel with a highest data rate.
6. The method of claim 5 wherein a subchannel that is transmitted first in the plurality of subchannels includes a field to indicate whether other subchannels are also being transmitted.
7. The method of claim 6 wherein the field comprises a plurality of bits each of which corresponds to a particular subchannel and is used to indicate whether the corresponding subchannel is present in the segment allocated for transmitting control information.

8. The method of claim 1 wherein the one or more selection criteria are selected from the group consisting of a first criterion corresponding to a link quality associated with the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

9. A method for processing information in a communication system, comprising:
 - segregating a control channel into a plurality of subchannels each of which being operable at a specific data rate;
 - transmitting control information including resource allocation information from an access point to a user terminal on particular subchannel of the plurality subchannels selected for the user terminal, based on one or more selection criteria; and
 - decoding, at the user terminal, one or more subchannels of the plurality of subchannels to obtain control information designated for the user terminal.

10. The method of claim 9 wherein decoding comprises:
 - performing a decoding procedure to decode the one or more subchannels, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

11. The method of claim 10 further comprising:
 - terminating the decoding procedure if one of the plurality of conditions is met.

12. The method of claim 11 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels.

13. The method of claim 11 wherein the plurality of conditions includes a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels.

14. The method of claim 11 wherein the plurality of conditions includes a third condition indicating that all subchannels have been processed.

15. The method of claim 10 wherein performing a decoding procedure comprises:
determining whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel.
16. The method of claim 15 wherein the quality metric comprises a cyclic redundancy check (CRC).
17. The method of claim 10 wherein performing a decoding procedure comprises:
determining whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.
18. The method of claim 17 wherein the identifier comprises a Medium Access Control (MAC) identifier.
19. The method of claim 9 wherein the one or more selection criteria are selected from the group consisting of a first criterion corresponding to operating conditions of the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.
20. An apparatus for processing information in a communication system, comprising:
means for partitioning a control channel that is used for transmitting control information into a plurality of subchannels, each subchannel being operated at a specific data rate;
means for selecting, for each of one or more user terminals, one of the subchannels to be used for transmitting control information from an access point to the respective user terminal, based on one or more selection criteria; and
means for transmitting control information from the access point to a particular user terminal on a particular subchannel selected for the respective user terminal.

21. The apparatus of claim 20 wherein each subchannel is associated with a distinct set of operating parameters including a code rate, a modulation scheme, and an SNR.

22. The apparatus of claim 20 wherein the plurality of subchannels are transmitted sequentially in an order from a subchannel with a lowest data rate to a subchannel with a highest data rate.

23. The apparatus of claim 22 wherein a subchannel that is transmitted first in the plurality of subchannels includes a field to indicate whether other subchannels are also being transmitted.

24. The apparatus of claim 20 wherein the one or more selection criteria including a first criterion corresponding to a link quality associated with the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

25. An apparatus for processing information in a communication system, comprising:

means for segregating a control channel into a plurality of subchannels each of which being operable at a specific data rate;

means for transmitting control information including resource allocation information from an access point to a user terminal on particular subchannel of the plurality subchannels selected for the user terminal, based on one or more selection criteria; and

means for decoding, at the user terminal, one or more subchannels of the plurality of subchannels to obtain control information designated for the user terminal.

26. The apparatus of claim 25 wherein means for decoding comprises:

means for performing a decoding procedure to decode the one or more subchannels, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

27. The apparatus of claim 26 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels, a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels, and a third condition indicating that all subchannels have been processed.

28. The apparatus of claim 25 wherein means for performing a decoding procedure comprises:

means for determining whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel; and

means for determining whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

29. The apparatus of claim 25 wherein the one or more selection criteria including a first criterion corresponding to operating conditions of the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

30. An apparatus for processing information in a communication system, comprising:

a controller configured to select one of a plurality of control subchannels to send control information to a user terminal, based on one or more selection criteria, each subchannel being operable at a specific data rate; and

a transmitter to send the control information designated for the user terminal on the subchannel selected for the user terminal.

31. The apparatus of claim 30 wherein each subchannel is associated with a specific set of operating parameters, including a data rate at which control information is transmitted, a code rate, a modulation scheme, and an SNR.

32. The apparatus of claim 30 wherein the plurality of subchannels are transmitted sequentially in an order from a subchannel with a lowest data rate to a subchannel with a highest data rate.

33. The apparatus of claim 30 wherein the one or more selection criteria including a first criterion corresponding to a link quality associated with the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

34. An apparatus for processing information in a wireless communication system, comprising:

a receiver to receive information on one or more control subchannels each of which being operated at a specific data rate; and

a decoder to decode the one or more control subchannels to obtain control information designated for a particular user terminal, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

35. The apparatus of claim 34 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels, a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels, and a third condition indicating that all subchannels have been processed.

36. The apparatus of claim 34 wherein the decoder is configured to determine whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel and to determine whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

37. A machine-readable medium comprising instructions which, when executed by a machine, cause the machine to perform operations including:

partitioning a control channel that is used for transmitting control information into a plurality of subchannels, each subchannel being operated at a specific data rate;

selecting, for each of one or more user terminals, one of the subchannels to be used for transmitting control information from an access point to the respective user terminal, based on one or more selection criteria; and

transmitting control information from the access point to a particular user terminal on a particular subchannel selected for the respective user terminal.

38. The machine-readable medium of claim 37 wherein each subchannel is associated with a set of operating parameters, including a data rate at which control information is transmitted, a code rate, a modulation scheme, and an SNR.

39. The machine-readable medium of claim 37 wherein the one or more selection criteria including a first criterion corresponding to a link quality associated with the respective user terminal, a second criterion corresponding to quality of service requirements associated with the respective terminal, and a third criterion corresponding to a subchannel preference indicated by the respective terminal.

40. A machine-readable medium comprising instructions which, when executed by a machine, cause the machine to perform operations including:

receiving information on one or more control subchannels each of which being operated at a specific data rate; and

decoding the one or more control subchannels to obtain control information designated for a particular user terminal, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

41. The machine-readable medium of claim 40 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels, a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels, and a third condition indicating that all subchannels have been processed.

42. The machine-readable medium of claim 40 wherein the decoder is configured to determine whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel and to determine whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

43. A method for processing information in a system, comprising:
receiving information on one or more control subchannels each of which being operated at a specific data rate; and
decoding the one or more control subchannels to obtain control information designated for a particular user terminal, starting with a subchannel operated at a lowest data rate, until at least one of a plurality of conditions is met.

44. The method of claim 43 wherein the plurality of conditions includes a first condition indicating a failure to correctly decode one of the plurality of subchannels, a second condition indicating that control information designated for the user terminal has been obtained from one of the plurality of subchannels, and a third condition indicating that all subchannels have been processed.

45. The method of claim 43 wherein decoding comprises:
determining whether information transmitted on a subchannel has been correctly received, based on a quality metric corresponding to the respective subchannel; and
determining whether control information designated for the user terminal is present in the respective subchannel, based on an identifier associated with the user terminal.

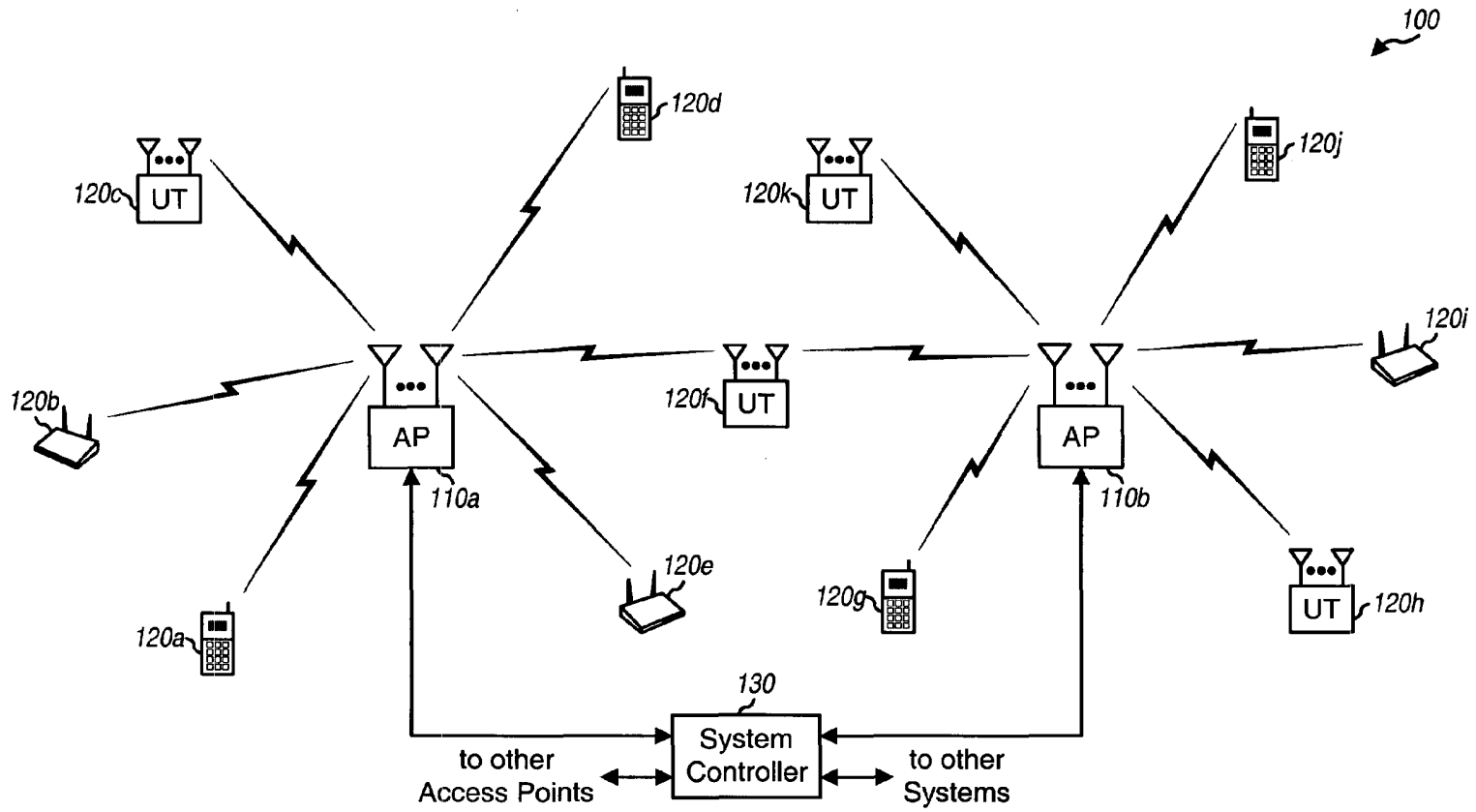


FIG. 1

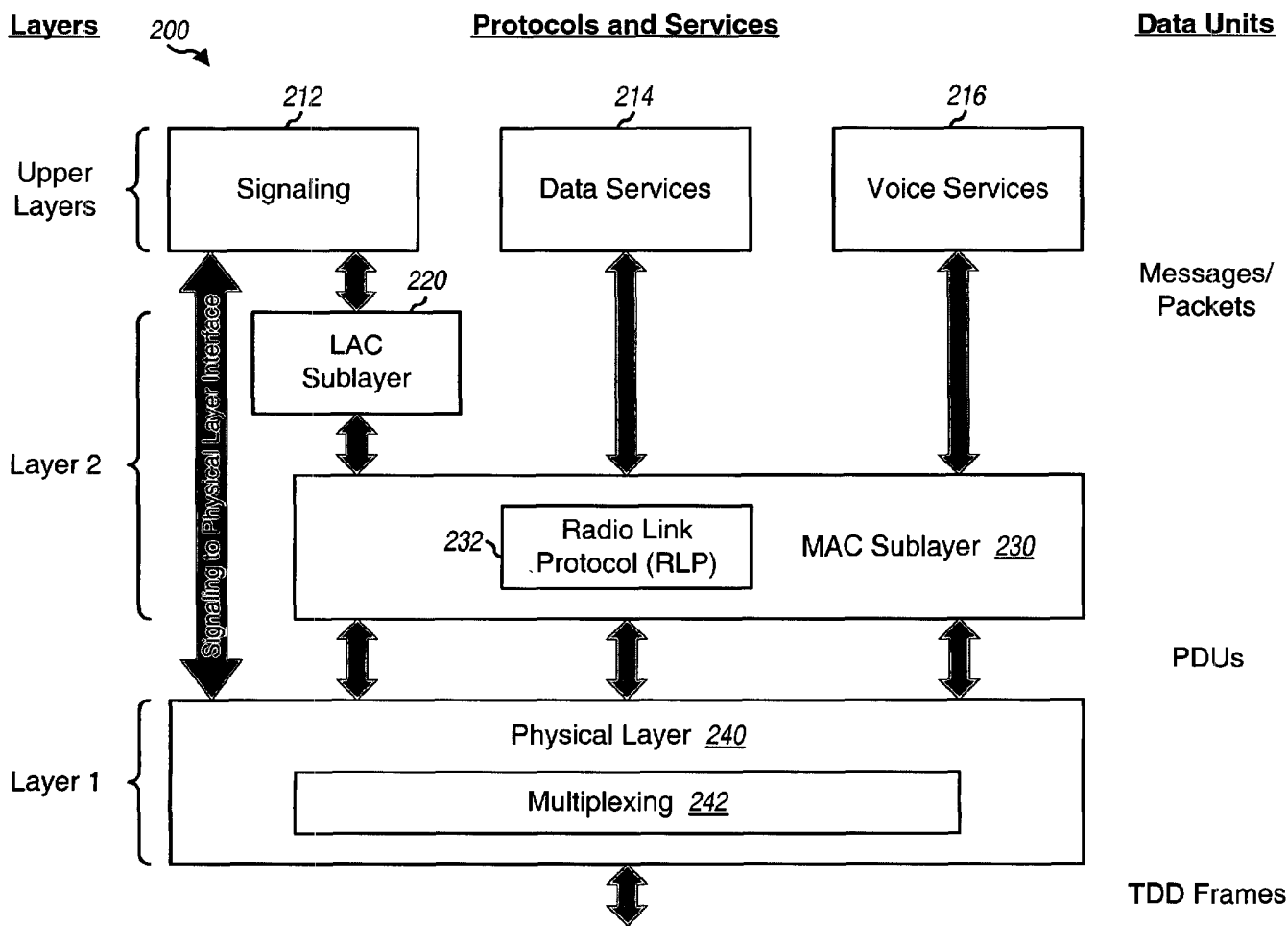


FIG. 2

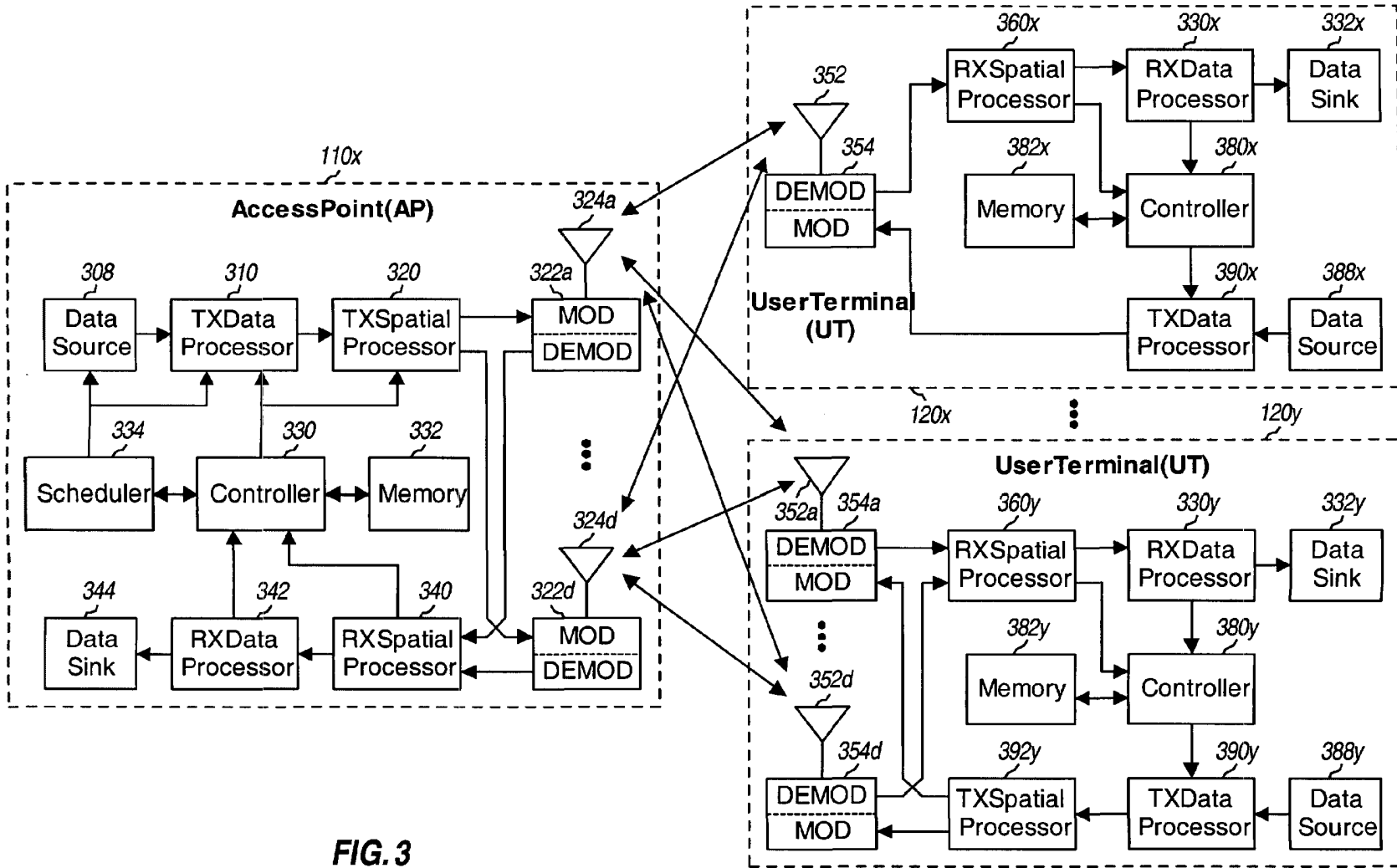


FIG. 3

TDD-TDM Frame Structure

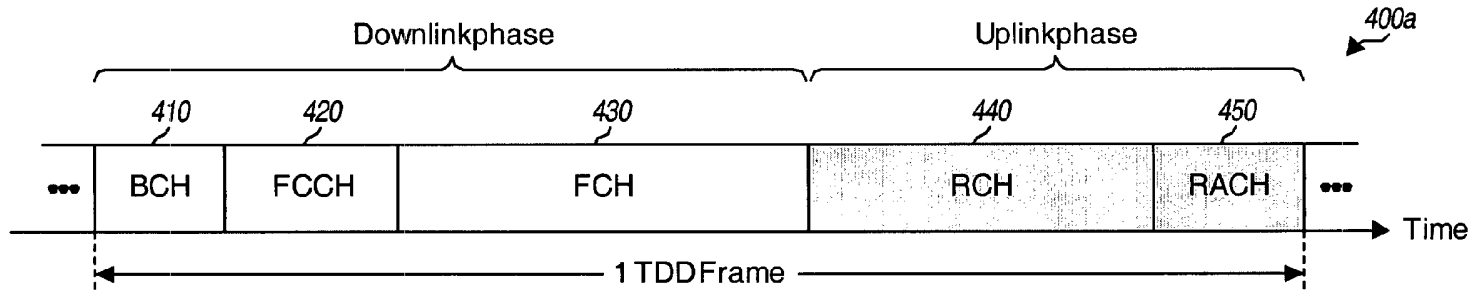


FIG. 4A

FDD-TDM Frame Structure

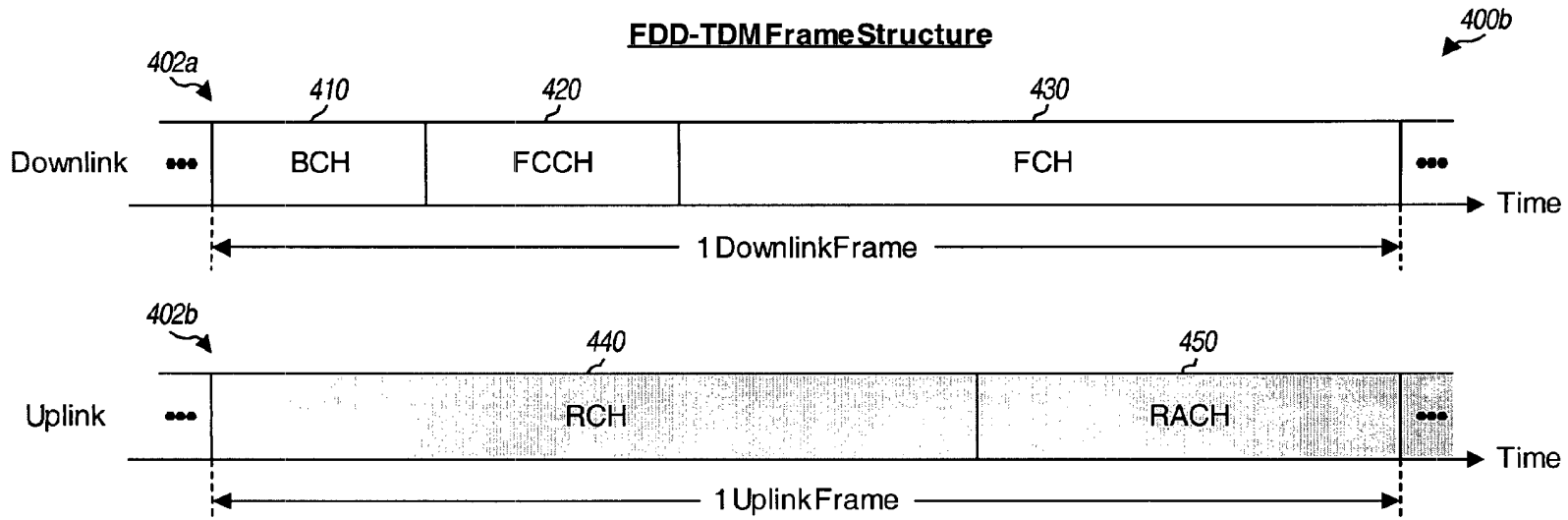


FIG. 4B

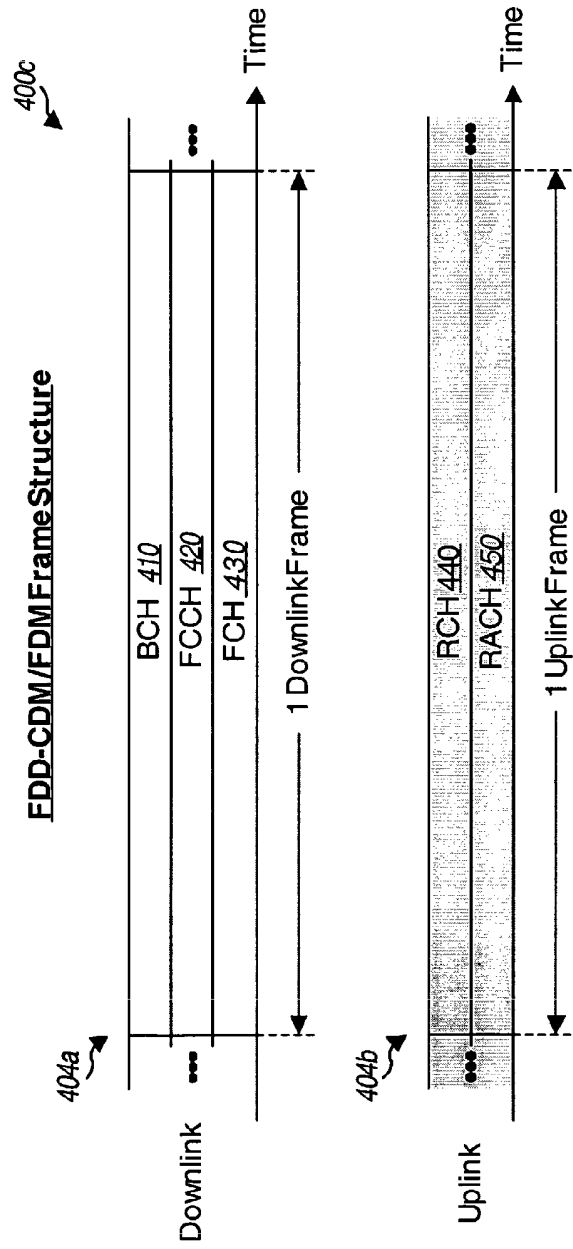


FIG. 4C

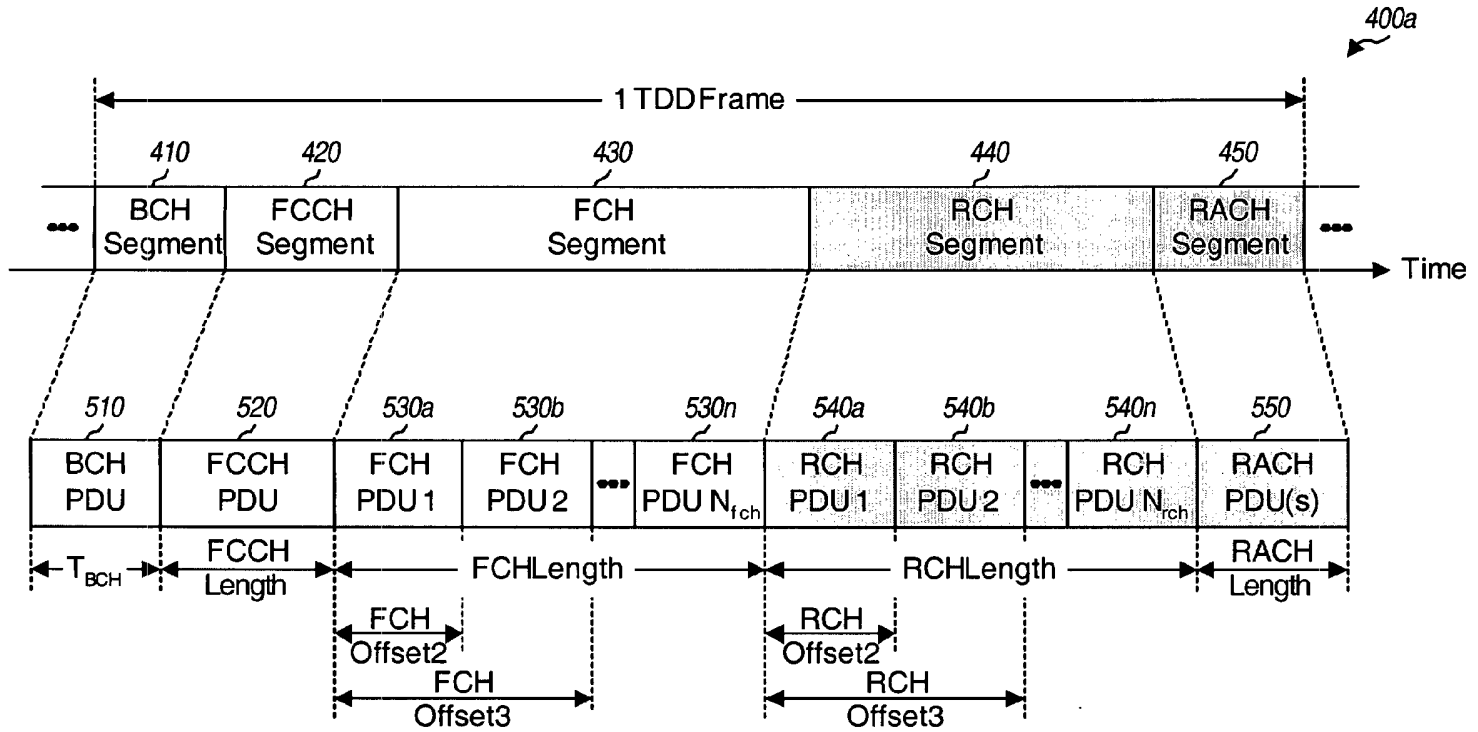


FIG. 5

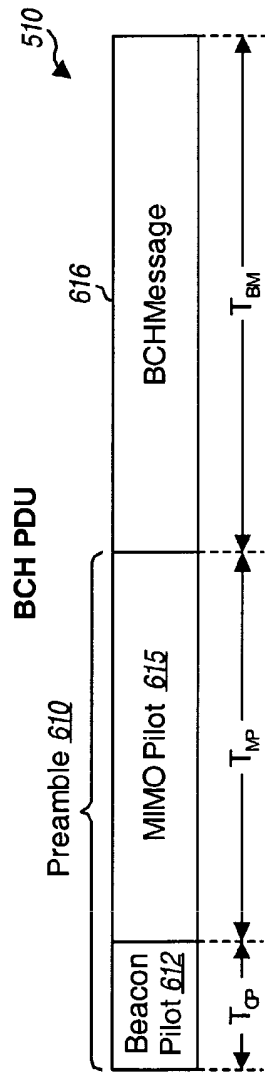


FIG. 6A

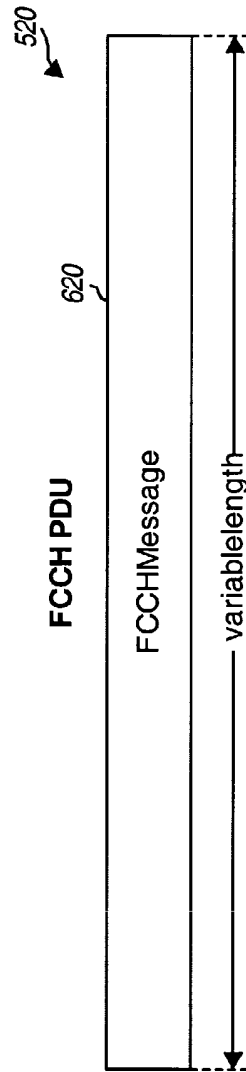


FIG. 6B

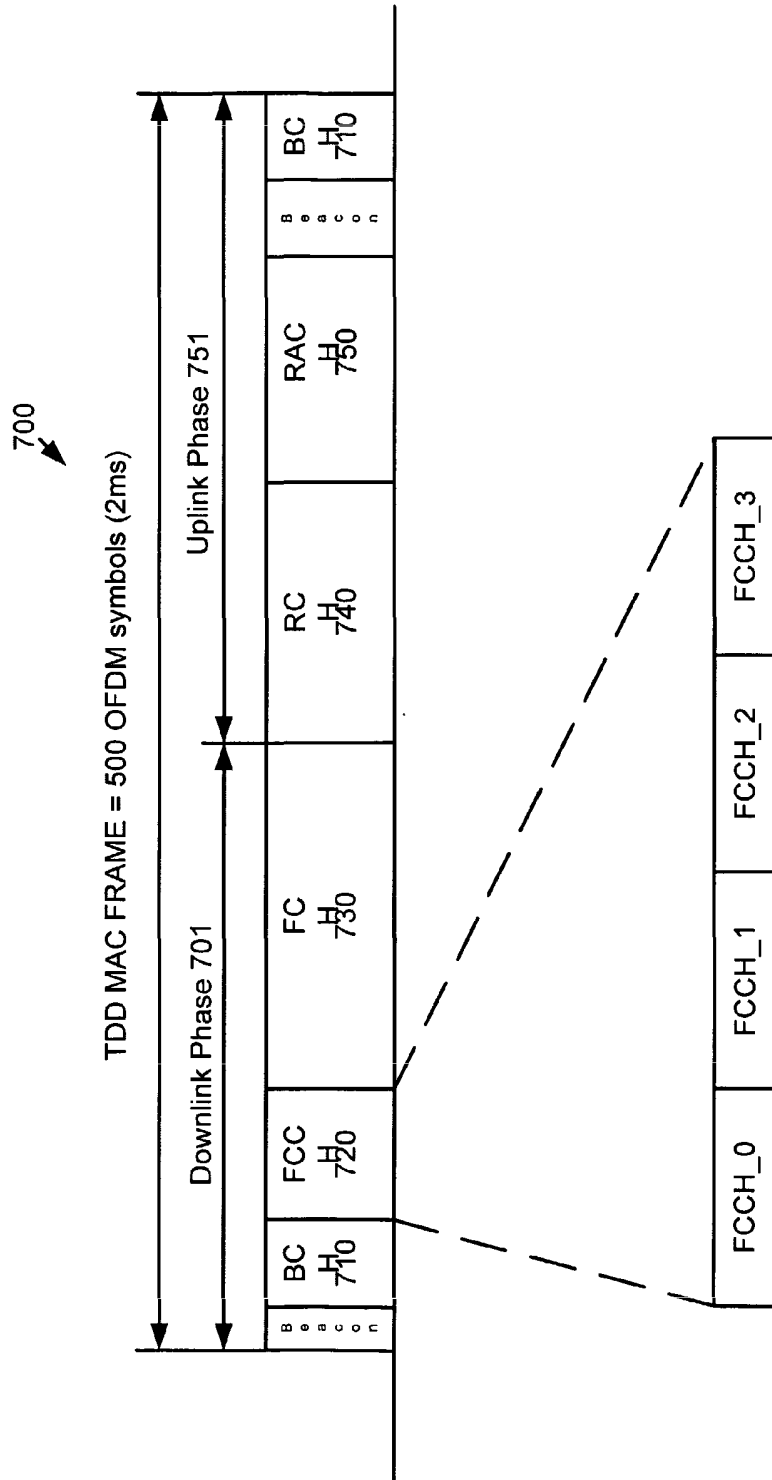


FIG. 7

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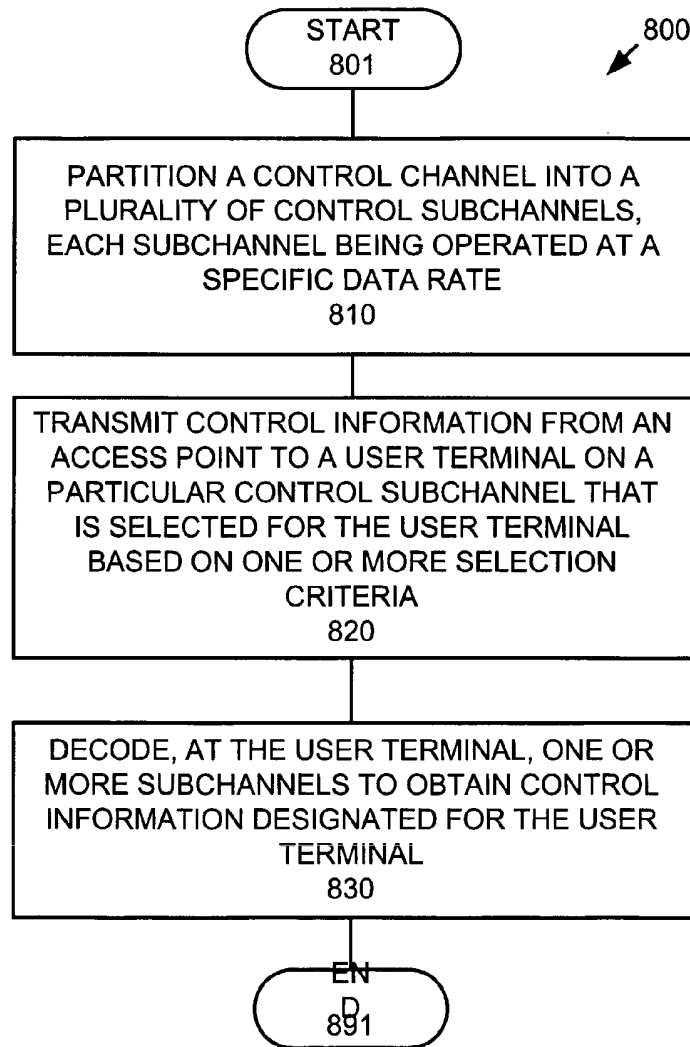


FIG. 8

10/10

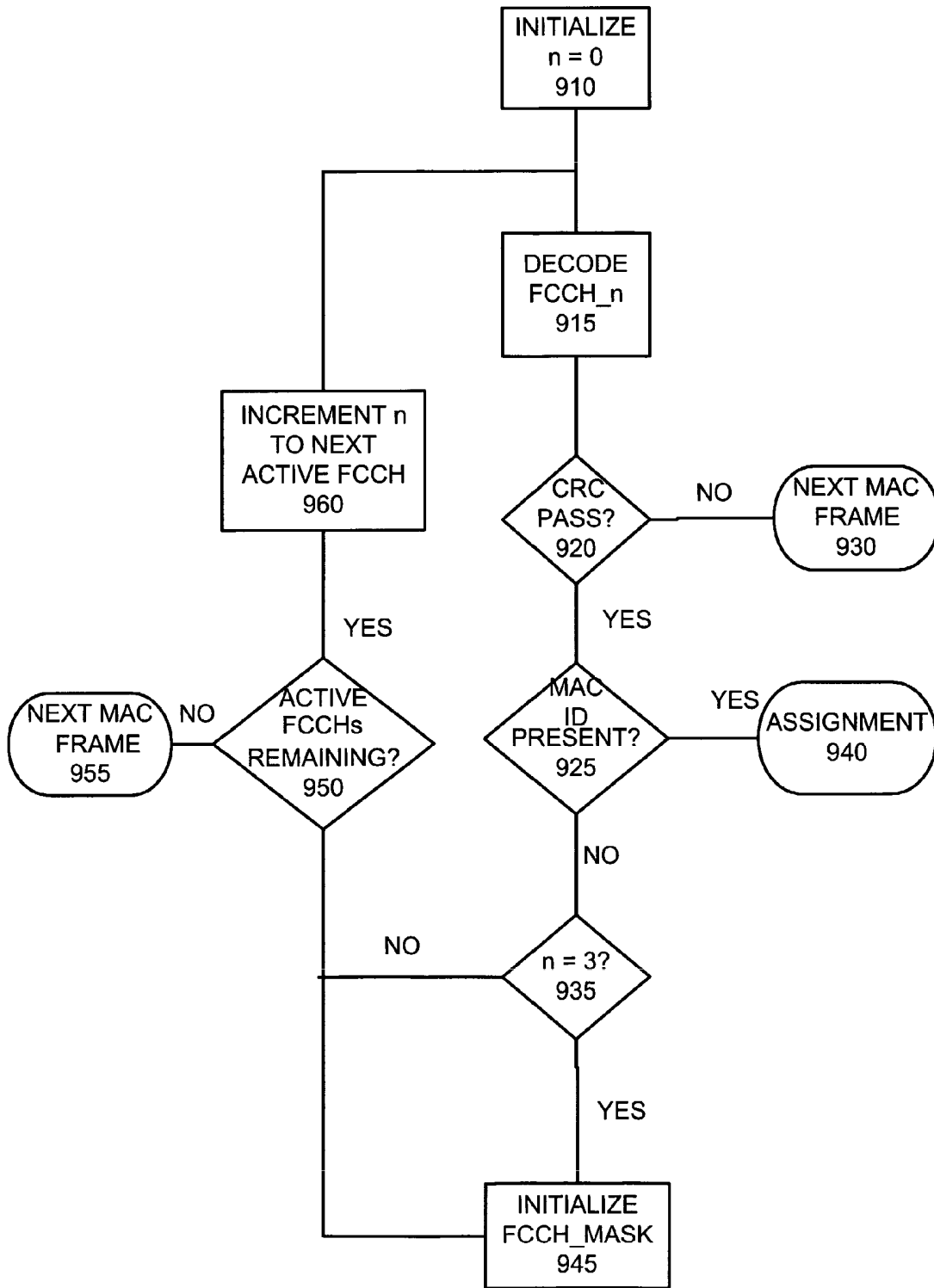


FIG. 9

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/038198

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/28 H04L12/56 H04Q7/38 H04L1/00 H04L27/26
H04L1/06 H04B7/26

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 H04B H04L 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)

EPO-Internal, WPI Data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/010984 A (NORTEL NETWORKS LIMITED) 6 February 2003 (2003-02-06) abstract page 1, line 1 - page 2, line 26 page 9, line 16 - page 19, line 11 figures 1-5 claims 1-18	1, 2, 9, 20, 25, 30, 34, 37, 40, 43
A	US 2002/071445 A1 (WU GENG ET AL) 13 June 2002 (2002-06-13) paragraphs '0001! - '0011! paragraphs '0023! - '0034! paragraphs '0047!, '0048! figures 1, 2a, 2b, 3a, 3b, 3c, 4a, 4b, 4c ----- -/--	1-45

Further documents are listed in the continuation of box C. Patent family members are listed in annex.

* Special categories of cited documents :

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

E earlier 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)

C 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 21 March 2005	Date of mailing of the international search report 04/04/2005
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Name and mailing address of the ISA European Patent Office, P.B. 5618 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Gavin Alarcon, 0
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INTERNATIONAL SEARCH REPORT

 International Application No
 PCT/US2004/038198

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Data Link Control (DLC) Layer; Part 1: Basic Data Transport Functions; ETSI TS 101 761-1" ETSI STANDARDS, EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE, SOPHIA-ANTIPO, FR, vol. BR, no. V131, December 2001 (2001-12), XP014006627 ISSN: 0000-0001 page 12 - page 14 page 16 page 18 - page 36 page 48 - page 53 pages 82-86	1-45
A	----- US 2003/147371 A1 (CHOI SUNG-HO ET AL) 7 August 2003 (2003-08-07) abstract paragraphs '0003!, '0005!, '0007! paragraphs '0019! - '0035! paragraphs '0038!, '0039! paragraphs '0062! - '0070! figures 1,3,4,11	1-45
A	----- US 2003/157953 A1 (DAS ARNAB ET AL) 21 August 2003 (2003-08-21) paragraphs '0001! - '0011! paragraphs '0023! - '0027! paragraphs '0041! - '0051! figure 6 -----	1-45

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/038198

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
WO 03010984	A	06-02-2003	WO 03010984 A1 US 2004013103 A1	06-02-2003 22-01-2004
US 2002071445	A1	13-06-2002	NONE	
US 2003147371	A1	07-08-2003	CN 1477886 A DE 10305096 A1 FR 2835669 A1 GB 2386513 A , B JP 2003284135 A KR 2003067556 A	25-02-2004 18-09-2003 08-08-2003 17-09-2003 03-10-2003 14-08-2003
US 2003157953	A1	21-08-2003	NONE	

Form PCT/ISA/210 (patent family annex) (January 2004)



Espacenet

Bibliographic data: JP2000102067 (A) — 2000-04-07

COMMUNICATION SYSTEM AND SLAVE SET

Inventor(s): HAMADA TOMOICHI; MORIYA YOICHI; KAWABATA TAKASHI; SOGABE TORU ±

Applicant(s): MITSUBISHI ELECTRIC CORP ±

Classification: - **international:** *H04J3/00; H04Q7/36;* (IPC1-7): H04J3/00; H04Q7/36
- **European:**

Application number: JP19980272924 19980928

Priority number (s): JP19980272924 19980928

Also published as: JP3436151 (B2)

Abstract of JP2000102067 (A)

PROBLEM TO BE SOLVED: To improve the frequency utilizing efficiency of operating frequency bands by dividing each of two frequency bands into carrier frequencies whose number is the same as a prescribed number of radio cells, assigning two carrier frequencies to each radio cell and operating a time division multiple access/time division duplex system with the respective frequencies.

SOLUTION: Frequency bands are divided into two frequency bands being upper and lower frequencies with an equal band width, and let number of repetition of cell arrangement be, e.g. 7, then the upper/lower frequency bands are divided respectively into 7 carrier frequencies f_1 - f_7 and f_1' - f_7' and two optional carrier frequencies are assigned as operating frequencies of each cell among the carrier frequencies in total of 14.; One system of a transmitter-receiver is enough by allocating slots of each carrier so that the slot assigned to the two carriers is not in duplicate at the same time and the configuration of the slave set is simplified.



Last updated: 14.03.2012 Worldwide Database 5.7.38; 93p

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(11) 特許出願公開番号

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(P2000-102067A)

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H 0 4 J 3/00		H 0 4 J 3/00	H 5 K 0 6 7

審査請求 未請求 請求項の数 6 O L (全 7 頁)

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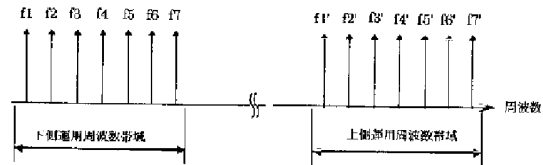
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(54) 【発明の名称】 通信方式及び子機装置

(57) 【要約】

【課題】 時分割多元接続/時分割複信 (TDMA/TDD) 通信方式に運用周波数帯が2つの領域に分離されて割当てられた場合、運用周波数帯全体の全てを有効に利用することができなかった。

【解決手段】 2つの周波数領域をそれぞれ繰返しセル数と同じキャリア数に分割し、各セルに対して各々割当てた2つのキャリアでTDMA/TDD通信方式を運用するようにした。



【特許請求の範囲】

【請求項1】 無線回線の多元接続方式として時分割多元接続/時分割複信方式を採用した無線セルでサービスエリアを覆い、一定の無線セル数毎に同一キャリア周波数による無線セルを繰返して配置する通信方式において、システムの運用周波数帯が2つの領域に分離して割当てられており、2つの領域の周波数帯のそれぞれを上記一定の無線セル数と同じ数のキャリア周波数に分割し、各無線セルに対してキャリア周波数を2つずつを割当て、それぞれのキャリア周波数で時分割多元接続/時分割複信方式を運用するとともに、各無線セル内の基地局と子機との間の通信に対して当該2つの時分割多元接続/時分割複信フレーム上からそれぞれタイムスロットを割当ててことを特徴とする通信方式。

【請求項2】 子機に割当てタイムスロットの位置が2つの時分割多元接続/時分割複信フレームにおいて同一時刻に重ならないように割当ててことを特徴とする請求項1記載の通信方式。

【請求項3】 2つに分離されたシステムの運用周波数帯は帯域幅が異なっており、各無線セルに対して割当てられるキャリア周波数は各々の領域から一つずつ割当てていことを特徴とする請求項1記載の通信方式。

【請求項4】 基地局から子機への同報チャンネルを2つのキャリア周波数上の時分割多元接続/時分割複信フレームにおいて各々送信し、子機は両同報チャンネルの内受信状況の良好な方を選択して受信することを特徴とする請求項1記載の通信方式。

【請求項5】 基地局からの2つの同報チャンネルを2つのキャリア周波数上の時分割多元接続/時分割複信フレームにおいて一定時間差があるタイムスロットで各々送信し、子機は両同報チャンネルの内受信状況の良好な方を選択して受信することを特徴とする請求項4記載の通信方式。

【請求項6】 請求項2の通信方式で基地局と通信する子機であって、送受信装置の送受信周波数を設定する局部発振器の発振周波数を2つのキャリア周波数の送受信のタイミングに応じて切換えるようにしたことを特徴とする子機装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】この発明は、一定の無線セル数毎に同一キャリア周波数による無線セルを繰返して配置する通信方式において、例えば、多元接続方式として時分割多元接続/周波数分割複信方式などを運用することを考慮して、2つの領域に分離して割当てられたシステムの運用周波数帯で時分割多元接続/時分割複信方式を運用するための方式及び子機装置に関するものである。

【0002】

【従来の技術】時分割多元接続/時分割複信(Time

Division Multiple Access / Time Division Duplex 以下、TDMA/TDDと称す。)通信方式を採用するセルラ通信方式に対する運用周波数の割当て例として、“第二世代コードレス電話システム標準規格”(RCR STD-28、財団法人電波システム開発センター、平成5年12月20日策定)の第3.2.1項無線周波数帯(以下、文献1と称す。)に記載されたものがある。文献1にも示されているように、TDMA/TDD通信方式においては、一般的に一つのまとまった周波数帯域において複数のキャリア周波数が割当てられる。また、セルラ通信方式については“移動通信の基礎”、奥村善久、進士昌明監修、昭和61年電子情報通信学会発行の第8章(以下、文献2と称す。)に述べられている。以下、上記のような一つのまとまった領域の周波数帯を割当ててTDMA/TDDによるセルラ通信方式について概略を説明する。

【0003】図9はTDMA/TDD方式で使用されるフレーム構成の一例である。TDMA/TDD方式では時間領域で複数のチャンネルを構成するためにフレームをチャンネルに対応するタイムスロット(以下、単にスロットと略称する。)に分割している。図において、Bは下り放送チャンネル用スロットで、基地局から無線セル(以下、単にセルと略称する。)内の複数の子機に向けた同報チャンネルで子機全体に対する制御情報や個々の子機に対する制御情報などが含まれる。また、下り放送チャンネル用スロットBはセル内のTDMA/TDDフレームの時間基準としても利用される。Rは上りランダムアクセス用スロットで、セル内の子機から基地局に向けた制御チャンネルで子機側から通信要求を行う時などに使用する。一般的に、このRチャンネルはそれぞれの子機がランダムにアクセスする方式がとられることが多い。U1からUmまでのスロットは子機から基地局に向けた通信チャンネル(上り通信チャンネル)、D1からDnまでのスロットは基地局から子機に向けた通信チャンネル(下り通信チャンネル)である。

【0004】このようにTDMA/TDD通信方式では1フレーム内に複数の上り通信チャンネルU1~Umと下り通信チャンネルD1~Dnを設けることにより、1つのキャリア周波数で基地局と複数の子機間の全二重通信を行うようにしている。文献1はTDMA/TDD通信方式を採用している第二世代コードレス電話システム(PHS)の周波数割当てを示しているが、本発明を端的に説明するため、従来のキャリア周波数の割当て例を図10に示す。図10においてはシステムに割当てられた運用周波数帯を7つのキャリア周波数f1~f7に分割している。キャリア周波数f1~f7は分割されたそれぞれの周波数帯の中心周波数である。また、図11は文献2にも述べられている7セル繰返しによるセル配置の一例であり、図において1~7はセルであり、それぞれの

セルでは、それらの中に記入された図10に対応するキャリア周波数1~7を使用していることを示している。

【0005】また、図12はTDMA/TDD通信方式で使用される基地局と子機の送受信装置の概略構成図であり、図において8は送受信アンテナ、9は送信系回路、10はこの送信系回路9に送信データを入力する送信データ入力端子、11は受信系回路、12はこの受信系回路11が受信データを出力する受信データ出力端子、13はアンテナ8を送信系回路9又は受信系回路11の何れかに接続するスイッチ、14は送信系回路9及び受信系回路11の送受信周波数を設定・選択する局部発信器、15は送受信制御及びスイッチ13の切換タイミングを制御する制御回路、16は制御信号の入力端子である。

【0006】例えば、図11のセル1内で基地局と通信する子機を例に信号の送受信の動作を図12で説明する。図12において、送信データは送信データ入力端子10に入力される。入力されたデータは送信系回路9でデジタル変調され送信キャリア周波数 f_1 でTDMAフレーム上の所定のスロット（上り通信チャンネル） $U_1 \sim U_m$ において送信系回路9の出力側からスイッチ13を経由してアンテナ8に接続され基地局に向けて送信される。一方、アンテナ8で受信された基地局からのキャリア周波数 f_1 の電波はスイッチ13を経由して受信系回路11に導かれ受信処理され受信データ出力端子12に出力される。なお、送受信系回路9、11の送受信周波数は、局部発信器14の設定によって f_1 が選択される。また、制御回路15は制御信号の入力端子16からの制御信号によってアンテナ8の切換えや送受信系回路9、11の処理内容を制御する。

【0007】以上のように、TDMA/TDD通信方式ではそれぞれのセルに割当てられたキャリア上で図9の例のようなTDMA/TDDフレームを構成し、基地局と子機の送信を時間軸上で区分けすることにより同一のキャリア周波数で基地局と複数の子機が通信を行うことができる。

【0008】上記したように、TDMA/TDD通信方式では送受信を同一のキャリア上で時間で区分けして行う。このため、各セルに対する周波数割当てに関しては、システムの運用周波数帯を繰返しセル数で等分し、それぞれの周波数帯を繰返しセル群（図11の例ではセル1~7）を構成するセルに順に割当て、繰返しセル数毎にこれらの周波数帯を繰返し利用するのが基本である。

【0009】

【発明が解決しようとする課題】従来のTDMA/TDD通信方式においては、図10及び図11のようにまとまった周波数帯域内でキャリア周波数が割当てられることが一般的である。しかしながら、TDMA/TDD通信方式の運用周波数帯が、例えば基地局とそれぞれの子

機の送信の区別を周波数領域で行う時分割多元接続/周波数分割複信（Time Division Multiple Access / Frequency Division Duplex: 以下、TDMA/FDDと称す。）方式を採用するシステムとの混在や選択的な使用を考慮し、図13に示すように上下2つの周波数領域に分離され割当てられることもある。これは、TDMA/FDD通信方式にとっては運用周波数帯がある程度以上の周波数差がある上りチャンネル用と下りチャンネル用の2つの周波数領域に分けられていることが必須であり、一方TDMA/TDD通信方式は基本的には運用周波数帯が一つにまとめられていても、2つに分けられていても対応できるためである。

【0010】しかしながら、例えば図11に示した繰返しセル数7のセル配置において、図13のように上下2つの等しい帯域幅の運用周波数帯が割当てられたとすると、図11のセル配置を構成するために必要な7つのキャリア周波数に割当てられた運用周波数帯の全体を等分することはできない。このため図13に示すように、例えば上下の周波数帯をそれぞれ4つ、すなわち合計8つの周波数帯に等分しその内7つの周波数帯を図11のように割当てたとすると、1キャリア周波数が余ってしまい与えられた運用周波数帯の全てを有効に利用することができないという主たる問題があった。

【0011】この発明は上記のような問題を解消するためになされたもので、2つの領域に分離されて割当てられた運用周波数帯を使用して周波数利用効率の良いTDMA/TDD通信方式によるセルラ通信を行うことを目的としており、さらにこれを実現するための送受信装置が簡単に構成できる方式及び装置を提供すること、及び2つの領域に分割されていることを利用し通信の信頼性を高める方式を提供することを目的としている。

【0012】

【課題を解決するための手段】この発明の請求項1に係る通信方式は、無線回線の多元接続方式として時分割多元接続/時分割複信方式を採用した無線セルでサービスエリアを覆い、一定の無線セル数毎に同一キャリア周波数による無線セルを繰返し配置する通信方式において、システムの運用周波数帯が2つの領域に分離して割当てられており、2つの領域の周波数帯のそれぞれを上記一定の無線セル数と同じ数のキャリア周波数に分割し、各無線セルに対してキャリア周波数を2つずつを割当て、それぞれのキャリア周波数で時分割多元接続/時分割複信方式を運用するとともに、各無線セル内の基地局と子機との間の通信に対して当該2つの時分割多元接続/時分割複信フレーム上からそれぞれタイムスロットを割当てるようにしたものである。

【0013】この発明の請求項2に係る通信方式は、請求項1における通信方式であって、子機に割当てるとタイムスロットの位置が2つの時分割多元接続/時分割複信

フレームにおいて同一時刻に重ならないように割当てるようにしたものである。

【0014】この発明の請求項3に係る通信方式は、請求項1における通信方式であって、2つに分離されたシステムの運用周波数帯は帯域幅が異なり、各無線セルに対して割当てたキャリア周波数は各々の領域から一つずつ割当てるようにしたものである。

【0015】この発明の請求項4に係る通信方式は、請求項1における通信方式であって、基地局から子機への同報チャンネルを2つのキャリア周波数上の時分割多元接続/時分割複信フレームにおいて各々送信し、子機は両同報チャンネルの内受信状況の良好な方を選択して受信するようにしたものである。

【0016】この発明の請求項5に係る通信方式は、請求項4における通信方式であって、基地局からの2つの同報チャンネルを2つのキャリア周波数上の時分割多元接続/時分割複信フレームにおいて一定時間差があるタイムスロットで各々送信し、子機は両同報チャンネルの内受信状況の良好な方を選択して受信するようにしたものである。

【0017】この発明の請求項6に係る通信方式は、請求項2の通信方式で基地局と通信する子機であって、送受信装置の送受信周波数を設定する局部発振器の発振周波数を2つのキャリア周波数の送受信のタイミングに応じて切換えるように構成したものである。

【0018】

【発明の実施の形態】実施の形態1. 以下、この発明の実施の形態1を図について説明する。図1は下側と上側の等しい帯域幅の2つの領域に分離され割当てられたセルラ通信システムの運用周波数帯の例である。今、セル配置の例として繰返しセル数を7とする場合には、これら上下の周波数帯域をそれぞれ図中 $f_1 \sim f_7$ 及び $f_1' \sim f_7'$ で示したように7つのキャリア周波数に分割し、合計14のキャリア周波数の中から任意の2キャリア周波数を各セルの運用周波数として割当てる。

【0019】図2に繰返しセル数が7の場合のセル配置とこの実施の形態によるキャリア周波数割当ての例を示す。図において、1～7はセルであり、それぞれのセル1～7では、それらの中に記入された図1に対応するキャリア周波数を使用することを例として示している。それぞれのキャリア周波数で運用されるTDMA/TDDのフレーム構成は基本的には図9の従来例で示したものと同様であり、図3は図2においてセル1で f_1 と f_2 のキャリア周波数で運用されるTDMA/TDDのフレーム構成の例を示す。図において各スロット信号の機能は図9に示した従来のTDMA/TDDフレームの例と同様である。また、図中ハッチングしたスロットはセル1内のある子機と基地局の間の通信に割当てられたスロットを示している。この図に示すように2つのキャリアの両方にスロットが割当てられる場合には、同一時刻に

おける割当てを避けると同時に、必要に応じて一定以上の時間差を設けて割当てるようにすることによって送受信機の構成を簡単にすることができる。

【0020】すなわち、図2のように各セルに2つの送受信キャリアを割当てた場合の信号の送受信は同一時刻に2つのキャリアのスロットが割当てられる場合を想定して基本的には図4に示すように図12の従来例で示した送受信装置を各々のキャリアに対応し、各基地局と子機に各々2つずつ設置する必要がある。しかしながら、図3に示したように2つのキャリア上に割当てられるスロットが同一時刻に重ならないように各キャリアのスロットを割り当てておけば図5に示すように送受信周波数を選択する局部発振器14aの周波数を f_1 の送受信と f_2 の送受信に該当するスロットのタイミングに合わせて切換えることにより送受信装置は1系統だけでよくなり、装置構成を簡単にすることができる。なお、図4において図12と同じ記号で示した回路は図12のそれぞれの回路と同じ機能の回路であり、また、17は例としてここではキャリア周波数 f_1 を、また、18は例としてキャリア周波数 f_2 を送受信する装置である。

【0021】また、図5においても図12と同じ記号で示した回路は図12のそれぞれの回路と同じ機能の回路であり、図中、14aは送受信回路の送受信周波数を選択する局部発振器であるが、図3の例で示したTDMA/TDDフレーム上に割当てられた送受信スロットに対応して送受信周波数を f_1 か f_2 に切換えて選択する機能を有している。

【0022】実施の形態2. 図6はこの発明の実施の形態2に係る運用周波数の分割例を示す図である。図6は図1において運用周波数帯の下側と上側の帯域幅が異なる場合の周波数分割例であり、それぞれの運用周波数帯を繰返しセル数と同じ数に分割している。この場合の各セルに対するキャリア周波数の割当て例を図7に示す。図中に示すように各セル1～7には上下の運用周波数領域からキャリア周波数を1つずつ割当てることにより、各セル1～7毎に同等の帯域を割当てることのできる。このような場合の装置構成は図4と同じであるが、17と18の送受信装置の送受信帯域幅やデータの伝送速度は、図6に示した上下運用周波数帯に割当てられたキャリア周波数のそれぞれの帯域幅に応じて異なる。

【0023】実施の形態3. 図3に示したように、基地局から子機に向けた制御情報などを伝送するBチャンネルを両方のキャリア f_1 、 f_2 のTDMA/TDDフレームに設け、基地局は同一の情報量を両Bチャンネルで伝送し、子機はこれら両Bチャンネルを受信し、受信状況の良好な方の受信データを採用するようすれば、制御チャンネルの信頼性を向上させることができる。

【0024】実施の形態4. 図3で示した2つのキャリア f_1 、 f_2 上のそれぞれのTDMA/TDDフレームのBチャンネルのスロットを図8で示すように異なる位置

に配置し、子機はこれら両方のBチャンネルを受信し、受信状況の良好な方の受信データを採用するようになれば、制御チャンネルの信頼性をさらに向上させることができる。

【0025】

【発明の効果】この発明の請求項1における通信方式によれば、各無線セルに対してキャリア周波数を2つずつを割当て、それぞれのキャリア周波数で時分割多元接続/時分割複信方式を運用するとともに、各無線セル内の基地局と子機との間の通信に対して当該2つの時分割多元接続/時分割複信フレーム上からそれぞれタイムスロットを割当てたようにしたので、割当てられた周波数帯を余すことなく有効に利用することができる効果がある。

【0026】また、この発明の請求項2における通信方式によれば、子機に割当てるタイムスロットの位置が2つの時分割多元接続/時分割複信フレームにおいて同一時刻に重ならないように割当てたようにしたので、子機の送受信器の構成を簡単にすることができる効果がある。

【0027】また、この発明の請求項3における通信方式によれば、帯域幅の異なる2つの周波数帯から、各無線セルに対して割当てるキャリア周波数を各々の領域から一つずつ割当てるものとしたので、割当てられた周波数帯を余すことなく有効に利用することができ、かつ、各無線セルに同等の帯域を割当てることができる効果がある。

【0028】また、この発明の請求項4における通信方式によれば、2つのキャリア周波数上にそれぞれ送信されてくる同報チャンネルの内、受信状況の良好な方を選択して受信するようにしたので、制御チャンネルの信頼性を向上できる効果がある。

【0029】また、この発明の請求項5における通信方式によれば、2つの同報チャンネルを一定時間差のあるタイムスロットで送信するものとし、子機は受信状況の良好な方を選択して受信するようにしたので、制御チャンネルの信頼性をさらに向上できる効果がある。

【0030】さらに、この発明の請求項6における子機装置によれば、送受信装置の送受信周波数を設定する局部発振器の発振周波数を2つのキャリア周波数の送受信のタイミングに応じて切換えるようにした送受信器の構成を簡単にすることができる効果がある。

【図面の簡単な説明】

【図1】 この発明の実施の形態1に係る運用周波数帯の分割例を示す図である。

【図2】 この発明の実施の形態1に係る各無線セルに対するキャリア周波数の割当て例を示し図である。

【図3】 この発明の実施の形態1に係る時分割多元接続/時分割複信フレームの構成を示す図である。

【図4】 この発明の実施の形態1に係る送受信装置の構成を示すブロック図である。

【図5】 この発明の実施の形態1に係る送受信装置の他の構成を示すブロック図である。

【図6】 この発明の実施の形態2に係る運用周波数帯の分割例を示す図である。

【図7】 この発明の実施の形態2に係る各無線セルに対するキャリア周波数の割当て例を示し図である。

【図8】 この発明の実施の形態2に係る時分割多元接続/時分割複信フレームの構成を示す図である。

【図9】 従来の時分割多元接続/時分割複信フレームの構成を示す図である。

【図10】 従来の運用周波数帯の分割例を示す図である。

【図11】 従来の各無線セルに対するキャリア周波数の割当て例を示し図である。

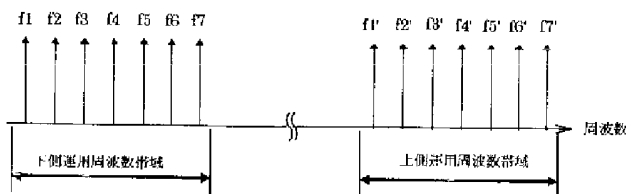
【図12】 従来の送受信装置の他の構成を示すブロック図である。

【図13】 従来の運用周波数帯の他の分割例を示す図である。

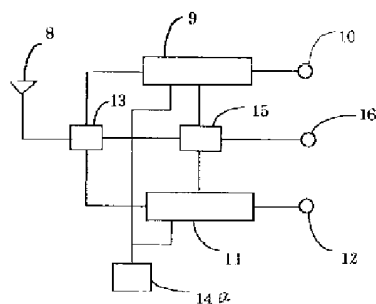
【符号の説明】

1～7 無線セル、 8 アンテナ、 9 送信系回路、 11 受信系回路、 14 局部発振器、 15 制御部。

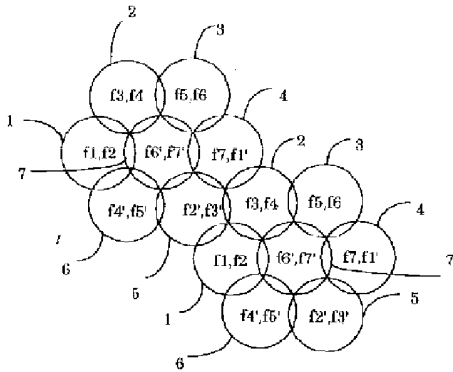
【図1】



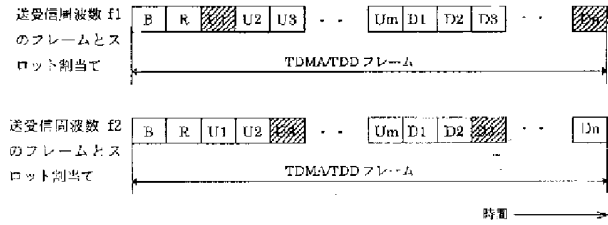
【図5】



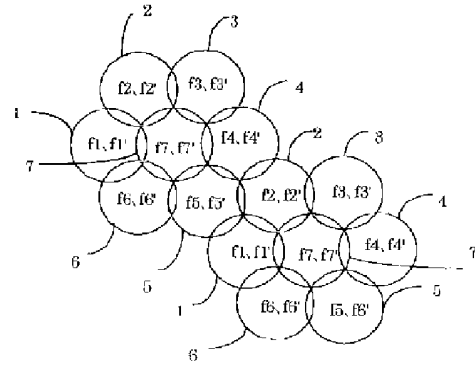
【図2】



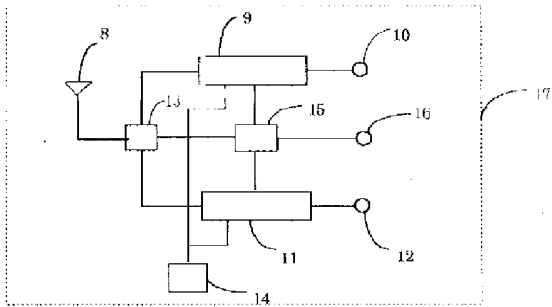
【図3】



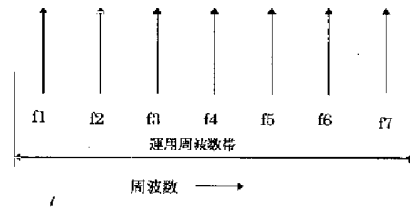
【図7】



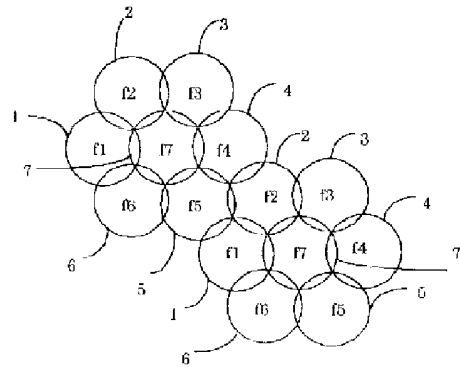
【図4】



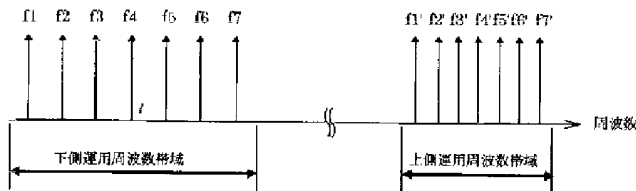
【図10】



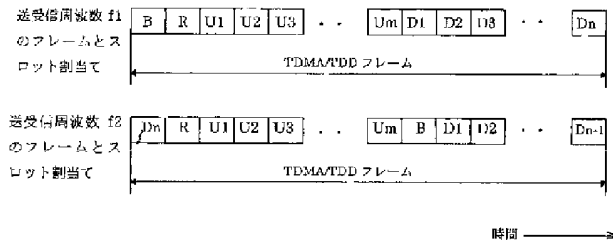
【図11】



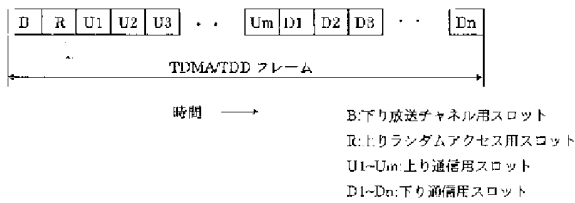
【図6】



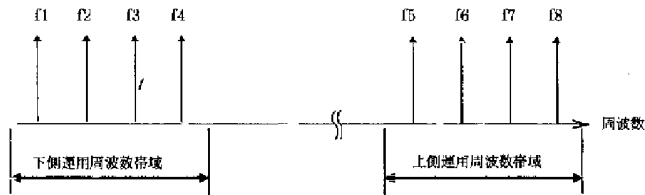
【図8】



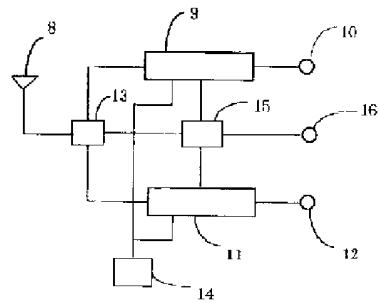
【図9】



【図13】



【図12】



フロントページの続き

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 EE61 EE71 JJ13 JJ17



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Bibliographic data: JP2001268051 (A) — 2001-09-28

UP-LINK PACKET TRANSMISSION METHOD IN MULTI-CARRIER/DS- CDMA MOBILE COMMUNICATION SYSTEM

Inventor(s): OKAWA KOICHI; SHIN HIROYUKI; ABETA SADAYUKI; SAWAHASHI MAMORU ±

Applicant(s): NTT DOCOMO INC ±

Classification: - **international:** H04B7/26; H04J1/00; H04J13/04; H04J3/16; H04L12/56; (IPC1-7): H04B7/26; H04J1/00; H04J13/04; H04J3/16; H04L12/56

- **European:** H04W74/02

Application number: JP20000081051 20000322

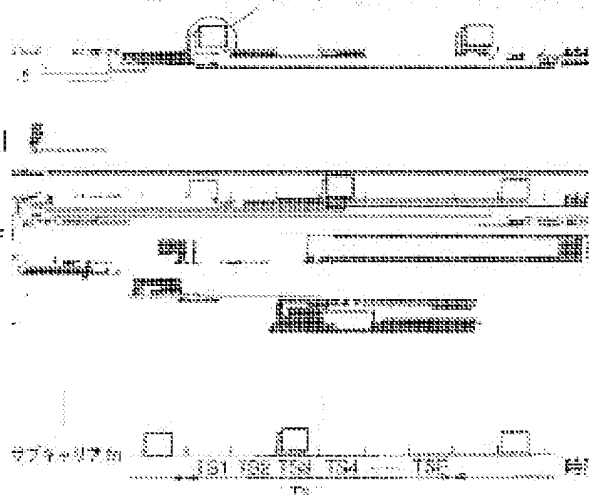
Priority number (s): JP20000081051 20000322

Abstract of JP2001268051 (A)

PROBLEM TO BE SOLVED: To provide an up-link packet transmission method in a novel multi- carrier DS-CDMA mobile communication system that can realize packet transmission at a variable transmission rate. **SOLUTION:** An operating frequency band is divided into n-sets (n is a natural number) of subcarrier f₁-f_n, and the subcarriers f₁-f_n are furthermore used in time division. A frame (frame length is TF and in common to all the subcarriers) is set to each subcarrier. Moreover, the frame is temporally divided into F-sets (F is a natural number) of time slots TS₁-TS_F (one time slot length TS=TF/F). A mobile station transmits a packet in matching the timing of this time slot. The packet can be furthermore multiplexed by applying spread processing to the packet in the same time slot by different spread codes by the principle of code division (CDMA).

マルチキャリア/DS-CDMA方式における移動局と
基地局間のチャネル構成の一例を示す図

同一スロット内で、CDMAによりパケットの多重化



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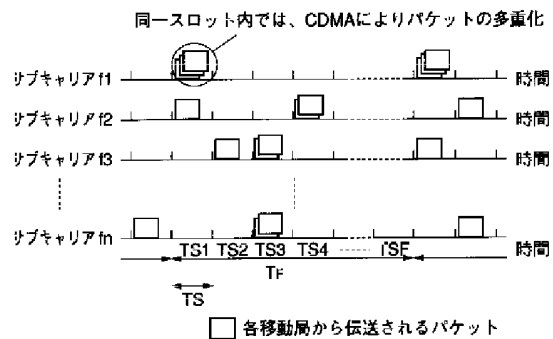
(54) 【発明の名称】 マルチキャリア/DS-CDMA移動通信システムにおける上りリンクパケット伝送方法

(57) 【要約】

【課題】 可変伝送速度のパケット伝送を実現することが可能な新規なマルチキャリア/DS-CDMA移動通信システムにおける上りリンクパケット伝送方法を提供することを目的とする。

【解決手段】 使用周波数帯をn個 (n:自然数) のサブキャリア $f_1 \sim f_n$ に分割して、このサブキャリア $f_1 \sim f_n$ を、更に、時分割で使用する。各サブキャリアにフレーム (フレーム長を T_F とする。全サブキャリアで共通とする。) を設定する。さらに、このフレームを、時間的にF個 (F:自然数) のタイムスロット $TS_1 \sim TS_F$ (1タイムスロット長 $TS = T_F / F$) に分割する。移動局は、このタイムスロットのタイミングに合わせてパケットを伝送する。同一のタイムスロット内では、パケットを異なる拡散符号により拡散することで、符号分割 (CDMA) の原理により、更に、多重化する。

マルチキャリア/DS-CDMA方式における移動局と基地局間のチャンネル構成の一例を示す図



【特許請求の範囲】

【請求項1】 n 個 (n は2以上の自然数)のサブキャリアを有するマルチキャリア/DS-SSMA移動通信システムにおける上りリンクパケット伝送方法において、

上記サブキャリアの通信チャネルそれぞれに、一定時間ごとの区切りであるフレームを設定し、さらに、前記フレームを時間的に F 個 (F は、2以上の自然数)に分割したタイムスロットを設定し、

移動局は、伝送すべきパケットを、前記タイムスロットのタイミングに合わせて、拡散符号により拡散して、基地局に伝送することを特徴とする上りリンクパケット伝送方法。

【請求項2】 請求項1記載の上りリンクパケット伝送方法において、

前記移動局は、パケット伝送するに当たり、前記基地局に、タイムスロット及び拡散符号の割り当てを、予約要求パケットを伝送して要求し、

前記基地局は、要求した移動局にタイムスロット及び拡散符号を割り当て、

前記移動局は、前記基地局から割り当てられたタイムスロットにおいて、割り当てられた拡散符号によりパケットを拡散して伝送することを特徴とする上りリンクパケット伝送方法。

【請求項3】 請求項1記載の上りリンクパケット伝送方法において、

前記移動局は、タイムスロットの割り当てを前記基地局に要求することなく、前記通信チャネルのいずれかのタイムスロットにランダムアクセスしてパケット伝送することを特徴とする上りリンクパケット伝送方法。

【請求項4】 請求項1記載の上りリンクパケット伝送方法において、

前記移動局が伝送するパケットの伝送量の大きさに応じて、前記移動局の伝送速度を変更することを特徴とする上りリンクパケット伝送方法。

【請求項5】 請求項2記載の上りリンクパケット伝送方法において、

前記基地局は、前記予約要求パケット伝送用のタイムスロットとして k_1 個 (k_1 は自然数、 $k_1 \leq F \times n$)を割り当て、さらに、予約要求パケットの拡散用として m_1 個 (m_1 は自然数、 $m_1 \leq$ 使用できる拡散符号の総数)の拡散符号を割り当て、

前記移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の1つで予約要求パケットを拡散して伝送することを特徴とする上りリンクパケット伝送方法。

【請求項6】 請求項5記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、

前記予約要求パケット伝送用のタイムスロットの個数 k_1 を変更することを特徴とする上りリンクパケット伝送方法。

【請求項7】 請求項5記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、

前記予約要求パケット伝送用の拡散符号の個数 m_1 を変更することを特徴とする上りリンクパケット伝送方法。

【請求項8】 請求項5記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、

前記予約要求パケット伝送用のタイムスロットの個数 k_1 及び前記予約要求パケット伝送用の拡散符号の個数 m_1 を変更することを特徴とする上りリンクパケット伝送方法。

【請求項9】 請求項5記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間における予約要求パケット数が多い場合、

前記移動局に予約要求パケットの伝送制限を通知し、

前記移動局は、その制限にしたがって予約要求パケットを伝送することを特徴とする上りリンクパケット伝送方法。

【請求項10】 請求項3記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局がランダムアクセスしてパケット伝送可能なタイムスロットとして k_2 個 (k_2 は自然数、 $k_2 \leq F \times n$)を割り当て、さらに、ランダムアクセスパケットの拡散用として m_2 個 (m_2 は自然数、 $m_2 \leq$ 使用できる拡散符号の総数)の拡散符号を割り当て、

前記移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の1つでランダムアクセスするパケットを拡散して伝送することを特徴とする上りリンクパケット伝送方法。

【請求項11】 請求項10記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、

前記ランダムアクセスパケット伝送用のタイムスロットの個数 k_2 を変更することを特徴とする上りリンクパケット伝送方法。

【請求項12】 請求項10記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、

前記ランダムアクセスパケット伝送用の拡散符号の個数 m_2 を変更することを特徴とする上りリンクパケット伝

送方法。

【請求項13】 請求項10記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、

前記ランダムアクセスパケット伝送用のタイムスロットの個数 k 2及び前記ランダムアクセスパケット伝送用の拡散符号の個数 m 2を変更することを特徴とする上りリンクパケット伝送方法。

【請求項14】 請求項10記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数が多い場合、

前記移動局にランダムアクセスパケットの伝送制限を通知し、

前記移動局は、その制限にしたがってランダムアクセスを行うことを特徴とする上りリンクパケット伝送方法。

【請求項15】 請求項4記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局の伝送量の大きさに応じて、移動局に p 個 (p は自然数、 $p \leq$ 使用できる拡散符号の総数) の拡散符号を割り当てることを特徴とする上りリンクパケット伝送方法。

【請求項16】 請求項4記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局の伝送量の大きさに応じて、前記移動局に異なる拡散率の拡散符号を割り当てることを特徴とする上りリンクパケット伝送方法。

【請求項17】 請求項4記載の上りリンクパケット伝送方法において、

前記基地局は、移動局の伝送量の大きさに応じて、移動局に q 個 (q は自然数、 $q \leq F \times n$) のタイムスロットを割り当てることを特徴とする上りリンクパケット伝送方法。

【請求項18】 請求項4記載の上りリンクパケット伝送方法において、

前記基地局は、前記移動局の伝送量の大きさに応じて、拡散符号数 p (p は自然数、 $p \leq$ 使用できる拡散符号の総数)、異なる拡散率の拡散符号、タイムスロット数 q (q は自然数、 $q \leq F \times n$) の内、少なくとも2つを変更させて割り当てを行うことを特徴とする上りリンクパケット伝送方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、マルチキャリア/DS-CDMA移動通信システムにおける上りリンクパケット伝送方法に関する。

【0002】

【従来の技術】マルチキャリア変調を用いた新しい符号分割多元接続(CDMA)方式が多数提案されている。

マルチキャリア/DS-CDMA方式は、その中の1つであり、"Performance of orthogonal CDMA codes for quasi-synchronous communication systems" (V. DaSilva, E. Sousa: Proc. of ICUPC'93, vol. 2, pp995-999, 1993)において、最初の検討がなされている。

【0003】マルチキャリア/DS-CDMAは、1つのキャリアでCDMA信号を送送するシングルキャリア/DS-CDMAとは異なり、無線伝送帯域を分割して複数のサブキャリアによりCDMA信号の並列伝送を行うものである。

【0004】これによりサブキャリア当たりの、情報伝送速度は小さくなり、それにとまって情報信号を拡散してCDMA信号を生成する拡散信号の速度も小さくなる。その結果、シングルキャリア/DS-CDMAに比較して、マルチキャリア/DS-CDMAでは拡散信号のチップ長が長くすることができる。チップ長が長くなれば、拡散符号どうしの同期ずれの影響が緩和される。この特徴を利用して、上記論文では、マルチキャリア/DS-CDMAを移動体通信システムの移動局から基地局への通信に適用し、準同期伝送を行う方法の提案を行っている。

【0005】また、マルチキャリア/DS-CDMAのリンクレベルでの性能評価が行われている。

【0006】"On the Performance of Multi-carrier DS-CDMA Systems," (S. Kondo and L. B. Milstein: IEEE Transactions on Communications, vol. 44, no. 2, pp. 238-246, February 1996)において、狭帯域干渉が存在する環境での性能評価では、マルチキャリア/DS-CDMAは、シングルキャリア/DS-CDMAよりも良好な特性となることが示されている。

【0007】

【発明が解決しようとする課題】しかし、従来のマルチキャリア/DS-CDMA方式に関する検討ではリンクレベルでの性能評価が中心であり、この方式を移動体通信システムに適用した場合に、どのようにして移動局が基地局と通信のやり取りを行うか、そのための制御信号をどのように伝送するかといった検討がなされていない。

【0008】さらに、これらの検討は、従来の移動体通信システムで通常用いられているような、送信機から受信機への信号伝送の際に、送信開始から終了まで常に専用の通信チャネルを確保する回線交換方式を基準にしたものである。

【0009】ところで、伝送すべき信号の伝送量の大き

さが多様化すると、回線交換方式では伝送の効率が悪くなる。一方、パケット伝送は、伝送量の多様な信号を効率良く伝送することができるので、伝送すべき信号の伝送量の大きさが多様化した場合は、パケット伝送が有効となる。

【0010】そこで、本発明は、可変伝送速度のパケット伝送を実現することが可能な新規なマルチキャリア/DS-CDMA移動通信システムにおける上りリンクパケット伝送方法を提供することを目的とするものである。

【0011】

【課題を解決するための手段】上記課題を解決するために、本件発明は、以下の特徴を有する課題を解決するための手段を採用している。

【0012】請求項1に記載された発明は、 n 個 (n は2以上の自然数)のサブキャリアを有するマルチキャリア/DS-CDMA移動通信システムにおける上りリンクパケット伝送方法において、上記 n 個サブキャリアの通信チャンネルそれぞれに、一定時間ごとの区切りであるフレームを設定し、さらに、前記フレームを時間的に F 個 (F は、2以上の自然数)に分割したタイムスロットを設定し、移動局は、伝送すべきパケットを、前記タイムスロットのタイミングに合わせて、拡散符号により拡散して、基地局に伝送することを特徴とする。

【0013】請求項2に記載された発明は、請求項1記載の上りリンクパケット伝送方法において、前記移動局は、パケット伝送するに当たり、前記基地局に、タイムスロット及び拡散符号の割り当てを、予約要求パケットを伝送して要求し、前記基地局は、要求した移動局にタイムスロット及び拡散符号を割り当て、前記移動局は、前記基地局から割り当てられたタイムスロットにおいて、割り当てられた拡散符号によりパケットを拡散して伝送することを特徴とする。

【0014】請求項3に記載された発明は、請求項1記載の上りリンクパケット伝送方法において、前記移動局は、タイムスロットの割り当てを前記基地局に要求することなく、前記通信チャンネルのいずれかのタイムスロットにランダムアクセスしてパケット伝送することを特徴とする。

【0015】請求項4に記載された発明は、請求項1記載の上りリンクパケット伝送方法において、前記移動局が伝送するパケットの伝送量の大きさに応じて、前記移動局の伝送速度を変更することを特徴とする。

【0016】請求項5に記載された発明は、請求項2記載の上りリンクパケット伝送方法において、前記基地局は、前記予約要求パケット伝送用のタイムスロットとして k_1 個 (k_1 は自然数、 $k_1 \leq F \times n$)を割り当て、さらに、予約要求パケットの拡散用として m_1 個 (m_1 は自然数、 $m_1 \leq$ 使用できる拡散符号の総数)の拡散符号を割り当て、前記移動局は、割り当てられたタイムス

ロットにおいて、割り当てられた拡散符号の1つで予約要求パケットを拡散して伝送することを特徴とする。

【0017】請求項6に記載された発明は、請求項5記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、前記予約要求パケット伝送用のタイムスロットの個数 k_1 を変更することを特徴とする。

【0018】請求項7に記載された発明は、請求項5記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、前記予約要求パケット伝送用の拡散符号の個数 m_1 を変更することを特徴とする。

【0019】請求項8に記載された発明は、請求項5記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間における予約要求パケット数に応じて、前記予約要求パケット伝送用のタイムスロットの個数 k_1 及び前記予約要求パケット伝送用の拡散符号の個数 m_1 を変更することを特徴とする。

【0020】請求項9に記載された発明は、請求項5記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間における予約要求パケット数が多い場合、前記移動局に予約要求パケットの伝送制限を通知し、前記移動局は、その制限にしたがって予約要求パケットを伝送することを特徴とする。

【0021】請求項10に記載された発明は、請求項3記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局がランダムアクセスしてパケット伝送可能なタイムスロットとして k_2 個 (k_2 は自然数、 $k_2 \leq F \times n$)を割り当て、さらに、ランダムアクセスパケットの拡散用として m_2 個 (m_2 は自然数、 $m_2 \leq$ 使用できる拡散符号の総数)の拡散符号を割り当て、前記移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の1つでランダムアクセスするパケットを拡散して伝送することを特徴とする。

【0022】請求項11に記載された発明は、請求項10記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、前記ランダムアクセスパケット伝送用のタイムスロットの個数 k_2 を変更することを特徴とする。

【0023】請求項12に記載された発明は、請求項10記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、前記ランダムアクセスパケット伝送用の拡散符号の個数 m_2 を変更することを特徴とする。

【0024】請求項13に記載された発明は、請求項10記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数に応じて、前記ランダムアクセス

パケット伝送用のタイムスロットの個数 k 2及び前記ランダムアクセスパケット伝送用の拡散符号の個数 m 2を変更することを特徴とする。

【0025】請求項14に記載された発明は、請求項10記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局からの所定期間におけるランダムアクセスするパケット数が多い場合、前記移動局にランダムアクセスパケットの伝送制限を通知し、前記移動局は、その制限にしたがってランダムアクセスを行うことを特徴とする。

【0026】請求項15に記載された発明は、請求項4記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局の伝送量の大きさに応じて、移動局に p 個 (p は自然数、 $p \leq$ 使用できる拡散符号の総数)の拡散符号を割り当てることを特徴とする。

【0027】請求項16に記載された発明は、請求項4記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局の伝送量の大きさに応じて、前記移動局に異なる拡散率の拡散符号を割り当てることを特徴とする。

【0028】請求項17に記載された発明は、請求項4記載の上りリンクパケット伝送方法において、前記基地局は、移動局の伝送量の大きさに応じて、移動局に q 個 (q は自然数、 $q \leq F \times n$)のタイムスロットを割り当てることを特徴とする。

【0029】請求項18に記載された発明は、請求項4記載の上りリンクパケット伝送方法において、前記基地局は、前記移動局の伝送量の大きさに応じて、拡散符号数 p (p は自然数、 $p \leq$ 使用できる拡散符号の総数)、異なる拡散率の拡散符号、タイムスロット数 q (q は自然数、 $q \leq F \times n$)の内、少なくとも2つを変更させて割り当てを行うことを特徴とする。

【0030】

【発明の実施の形態】次に、本発明の実施の形態について図面と共に説明する。

(チャンネル構成)図1は、マルチキャリア/DS-SS-CDMA方式における移動局と基地局間のチャンネル構成の一例を示す図である。

【0031】使用周波数帯を n 個 (n は2以上の自然数)のサブキャリア $f_1 \sim f_n$ に分割する。また、このサブキャリア $f_1 \sim f_n$ を時分割で使用。そのため、各サブキャリアにフレーム(一定時間ごとの区切りであり、フレーム長を T_F とする。このフレームは、全サブキャリアで共通とする。)を設定する。さらに、このフレームを、時間的に F 個 (F は、2以上の自然数)のタイムスロット $TS_1 \sim TS_F$ (1タイムスロット長 $TS = T_F / F$)に分割する。

【0032】したがって、全サブキャリアでは、1フレーム内に $F \times n$ 個のタイムスロットが存在する。

【0033】移動局は、このタイムスロットのタイミン

グに合わせてパケットを伝送する。また、同一のタイムスロット内では、パケットを異なる拡散符号により拡散することで、符号分割(CDMA)の原理により多重化する。

【0034】従って、図1のチャンネル構成では、 $F \times n \times$ (拡散符号多重数)の複数パケットの同時伝送が可能となる。

【0035】図1の例では、サブキャリア f_1 のタイムスロット TS_1 において、CDMAにより3つのパケットが多重化されている。

(タイムスロット及び拡散符号を予約してパケット伝送する方法)図2は、移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図である。

【0036】移動局は、まず、予約要求パケットを基地局に伝送して、パケットを伝送するためのタイムスロット及び拡散符号の割り当てを要求する(S101)。基地局は、移動局からの割り当て要求に対して、通信チャンネル上のタイムスロット及び拡散符号の割り当てを行い(S102)、その結果を移動局に通知する(S103)。

【0037】移動局は、基地局から割り当てられたタイムスロットで、かつ、割り当てられた拡散符号によりパケットを拡散して伝送する(S104)。

【0038】これにより、タイムスロット及び拡散符号を割り当てられた移動局のみが、割り当てられたタイムスロットにおいて、割り当てられた拡散符号を用いてパケットを拡散して伝送を行うことができる。

【0039】多くのタイムスロット又は多くの拡散符号を割り当てれば、同時に多くのパケットを伝送することができるので、伝送量が大きくなる。

【0040】また、一つのタイムスロット又は一つの拡散符号を割り当てた場合でも、移動局が割り当てられたタイムスロット及び割り当てられた拡散符号を優先して使用し、移動局が、伝送する情報がなくなるまで、周期的にかつ確実に伝送ができれば、結果として、伝送量の大きなパケットが伝送できることとなる。

(予約無しランダムアクセス)図3は、移動局から基地局にパケット伝送する際に、移動局と基地局で行われる制御のやり取りの一例を示す図である。

【0041】移動局は、通信チャンネル上のいずれかのタイムスロットにランダムアクセスしてパケットを伝送する(S111)。

【0042】ここで、パケットの伝送に成功すれば、パケットの伝送は終了となる(S112: YES)。失敗した場合には(S112: NO)、移動局は再び、通信チャンネル上のいずれかのタイムスロットにランダムアクセスしてパケットを伝送する(S111)。

【0043】このように、移動局が、タイムスロットの割り当てを前記基地局に要求することなく、通信チャネ

ルのいずれかのタイムスロットにランダムアクセスしてパケット伝送する方法は、移動局から基地局に伝送量の少ない信号をパケット伝送する場合に適する。

(伝送量に応じたタイムスロットと拡散符号の割り当て) 図4は、移動局が伝送すべきパケットの伝送量の大きさに応じて伝送速度を変更するための、移動局と基地局で行われる制御のやり取りの一例を示す図である。

【0044】移動局は、まず、予約要求パケットを基地局に伝送して、タイムスロット及び拡散符号の割り当てを要求するとともに、伝送量の大きさも伝える(S120)。

【0045】基地局は、移動局からの割り当て要求及び伝送量の情報に基づいて、通信チャンネル上に移動局の伝送量に応じたタイムスロットや拡散符号の割り当てを行い、その結果を移動局に通知する(S121)。

【0046】移動局は、この通知結果に基づいてパケット伝送を行う(S122)。

【0047】これにより、移動局が伝送するパケットの伝送量が大きければ、基地局は、大きな伝送量が伝送可能なタイムスロット(例えば、複数のタイムスロット)及び拡散符号(例えば、複数の拡散符号、拡散率の小さい拡散符号)の割当を行い、移動局が必要とする伝送量が小さければ、基地局は、それに見合ったタイムスロット及び拡散符号の割当を行う。

【0048】これにより、基地局は、移動局の伝送量に応じて、タイムスロットと拡散符号を適応的に割り当てる。

【0049】一方、移動局は、伝送する伝送量に応じた伝送速度を得ることができる。

(予約要求パケット伝送用のタイムスロットと拡散符号の割り当て) 次に、移動局が基地局に、予約要求パケットを伝送する場合に、基地局がどのように予約要求パケット伝送用のタイムスロットと拡散符号の割り当てを行うかを説明する。移動局から基地局には、図1に示したように、 $F \times n \times$ (拡散符号多重数) の複数パケットの同時伝送が可能となる。

【0050】本発明では、この $F \times n \times$ (拡散符号多重数) 中の幾つかを、予約要求パケット伝送に用いる。

【0051】図5は、一フレーム内に存在する $F \times n$ のタイムスロットの中から、基地局が予約要求パケット伝送タイムスロットとして任意の $k1$ 個 ($k1$: 自然数、 $k1 \leq F \times n$) を割り当てる。そして、移動局は、この予約要求パケット伝送タイムスロットにおいて、基地局によって、あらかじめ決められた $m1$ 個 ($m1$: 自然数、 $m1 \leq$ 使用できる拡散符号の総数) の拡散符号の1つで予約要求パケットを拡散して伝送する。

【0052】図5では、サブキャリア $f1$ のタイムスロットTS1、サブキャリア $f2$ のタイムスロットTS1、サブキャリア $f3$ のタイムスロットTS2等が、予約要求パケット伝送タイムスロットとして割り当てられ

ている。

【0053】図6の場合は、全サブキャリアにおいて、毎フレームごとに発生するタイムスロットTS1のタイムスロットを予約要求パケット伝送タイムスロットとして設定した場合($k1 = n$) のチャンネル構成の一例を示している。

【0054】図6は、 $f1 \sim f_n$ の全てのサブキャリアにおいて、タイムスロットTS1のタイムスロットを予約要求パケット伝送タイムスロットとして設定した場合である。

【0055】図7の場合は、全サブキャリアにおいて、タイムスロットTS1の一部を予約要求パケット伝送タイムスロットとして設定した場合($k1 < n$) のチャンネル構成の一例を示している。 $k1$ 個のタイムスロットの選び方は、サブキャリアを連続的に割り当てても、離散的に割り当ててもよい。

【0056】図7では、サブキャリア $f3$ のタイムスロットTS1は、予約要求パケット伝送タイムスロットとして、割り当てられていない。

【0057】図8の場合は、一つのサブキャリアの全タイムスロットを予約要求パケット伝送タイムスロットとして設定した場合($k1 = F$) のチャンネル構成の一例を示している。なお、予約要求パケット伝送タイムスロットを設定するサブキャリアは、2以上であってもよい。

【0058】図8では、サブキャリア $f1$ の全タイムスロットが、予約要求パケット伝送タイムスロットとして、割り当てられている。

【0059】図9の場合は、一つのサブキャリアの一部のタイムスロットを予約要求パケット伝送タイムスロットとして設定した場合($k1 < F$) のチャンネル構成の一例を示している。 $k1$ 個のタイムスロットの選び方は、タイムスロットを連続的に割り当てても、離散的に割り当ててもよい。

【0060】図9では、サブキャリア $f1$ のTS1、TS2、TS4等のタイムスロットが、予約要求パケット伝送タイムスロットとして、割り当てられている。

(予約要求パケット伝送用のタイムスロット数及び拡散符号数等の変更) 移動局からの所定期間における予約要求パケット数が多いと、予約要求に応じられないことがある。そこで、予約要求パケット数に応じて、予約要求パケット伝送用のタイムスロット数及び拡散符号数等を変更する。

【0061】図10の場合は、移動局からの所定期間における予約要求パケット数に応じて、基地局が予約要求パケット伝送タイムスロットの個数 $k1$ ($k1$: 自然数、 $k1 \leq F \times n$) を変更する際の、基地局で行われる制御の一例を示した図である。

【0062】基地局は、移動局から伝送された予約要求パケット数を、一定時間測定する(S130)。

【0063】測定した結果、予約要求パケット数がある

しきい値以上の場合 (S131: YES) は、予約要求パケット伝送スロット数を増加させ、そのタイムスロットの位置を移動局に通知する (S133)。

【0064】また、測定した結果、予約要求パケット数があるしきい値以下の場合 (S132: YES) は、予約要求パケット伝送スロット数を減少させ、そのタイムスロットの位置を移動局に通知する (S134)。

【0065】予約要求パケット数があるしきい値以上でなく (S131: NO)、かつ、予約要求パケット数があるしきい値以下でない (S132: NO) 場合は、予約要求パケット伝送スロット数は変更しない。

【0066】移動局は、基地局から通知された予約要求パケット伝送タイムスロットの位置にしたがって、予約要求パケットを送信する。

【0067】図11は、移動局からの所定期間における予約要求パケット数に応じて、基地局が予約要求パケット伝送用の拡散符号の個数 $m1$ ($m1$: 自然数、 $m1 \leq$ 使用できる拡散符号の総数) を変更する際の、基地局で行われる制御の一例を示した図である。

【0068】基地局は、移動局から伝送された予約要求パケット数を、一定時間測定する (S140)。

【0069】測定した結果、予約要求パケット数があるしきい値以上の場合 (S141: YES) は、予約要求パケットを拡散する拡散符号数 $m1$ を増加させ、その種類を移動局に通知する (S143)。

【0070】また、測定した結果、予約要求パケット数があるしきい値以下の場合 (S142: YES) は、予約要求パケットを拡散する拡散符号数 $m1$ を減少させ、その種類を移動局に通知する (S144)。

【0071】予約要求パケット数があるしきい値以上でなく (S141: NO)、かつ、予約要求パケット数があるしきい値以下でない (S142: NO) 場合は、予約要求パケットを拡散する拡散符号数は変更しない。

【0072】移動局は、基地局から通知された予約要求パケット伝送用の拡散符号の中から1つを選択して、予約要求パケットを拡散して送信する。

【0073】図12は、移動局からの所定期間における予約要求パケット数に応じて、基地局が前記予約要求パケット伝送タイムスロットの個数 $k1$ ($k1$: 自然数、 $k1 \leq F \times n$) 及び予約要求パケット伝送用の拡散符号の個数 $m1$ ($m1$: 自然数、 $m1 \leq$ 使用できる拡散符号の総数) を変更する際の基地局で行われる制御の一例を示した図である。

【0074】基地局は、移動局から伝送された予約要求パケット数を、一定時間測定する (S150)。

【0075】測定した結果、予約要求パケット数があるしきい値以上の場合 (S151: YES) は、「予約要求パケットを拡散する拡散符号数 $m1$ を増加」あるいは「予約要求パケット伝送スロット数 $k1$ を増加」あるいは「その双方を増加」させ、その情報を移動局に通知す

る (S153)。

【0076】また、測定した結果、予約要求パケット数があるしきい値以下の場合 (S152: YES) は、「予約要求パケットを拡散する拡散符号数 $m1$ を減少」あるいは「予約要求パケット伝送スロット数 $k1$ を減少」あるいは「その双方を減少」させ、その情報を移動局に通知する (S154)。

予約要求パケット数があるしきい値以上でなく (S151: NO)、かつ、予約要求パケット数があるしきい値以下でない (S152: NO) 場合は、「予約要求パケットを拡散する拡散符号数」及び「予約要求パケット伝送スロット数」は変更しない。

【0077】移動局は、基地局から通知された予約要求パケット伝送タイムスロットの位置、及び予約要求パケット伝送用の拡散符号の中から1つを選択して、予約要求パケットを拡散して送信する。

【0078】図13は、予約要求パケット数が多くなると、予約要求パケットの伝送が、的確に伝送されない恐れがあることから、基地局が移動局に予約要求パケットの伝送を制限 (例えば、予約要求パケットの伝送を時間的に制限する。) し、移動局がその制限にしたがって予約要求パケットを送信する場合の基地局で行われる制御の一例を示した図である。

【0079】基地局は、移動局から伝送された予約要求パケット数を、一定時間測定する (S160)。

【0080】測定した結果、予約要求パケット数があるしきい値以上の場合 (S161: YES) は、予約要求パケットの伝送制限を現状よりも厳しくし、移動局に通知する (S163)。

【0081】また、測定した結果、予約要求パケット数があるしきい値以下の場合 (S162: YES) には、予約要求パケットの伝送制限を現状よりも緩やかにし、移動局に通知する (S164)。

【0082】予約要求パケット数があるしきい値以上でなく (S161: NO)、かつ、予約要求パケット数があるしきい値以下でない (S162: NO) 場合は、伝送制限の変更を行わない。

(ランダムアクセス用のタイムスロット数及び拡散符号数等の割り当て) 基地局は、移動局がランダムアクセスしてパケット伝送可能なタイムスロットとして $k2$ 個 ($k2$: 自然数、 $k2 \leq F \times n$) を割り当て、さらに、ランダムアクセスパケットの拡散用として $m2$ 個 ($m2$: 自然数、 $m2 \leq$ 使用できる拡散符号の総数) の拡散符号を割り当てる。

【0083】移動局は、割り当てられたタイムスロットにおいて、割り当てられた拡散符号の1つでランダムアクセスするパケットを拡散して送信する。

【0084】図14に示されるように、一フレーム内に存在する $F \times n$ 個のタイムスロットの中から、基地局がランダムアクセスパケット伝送タイムスロットとして任

意の k_2 個 (k_2 : 自然数、 $k_2 \leq F \times n$) を割り当てる。そして、移動局はこのランダムアクセスバケット伝送タイムスロットにおいて、基地局によってあらかじめ決められた m_2 個 (m_2 : 自然数、 $m_2 \leq$ 使用できる拡散符号の総数) の拡散符号の1つでランダムアクセスバケットを拡散して伝送する。

【0085】図14では、サブキャリア f_1 のタイムスロットTS1、サブキャリア f_2 のタイムスロットTS1、サブキャリア f_3 のタイムスロットTS2等が、ランダムアクセスバケット伝送タイムスロットとして割り当てられている。

【0086】図15は、全サブキャリアにおいて、毎フレームごとに発生するタイムスロットTS1のタイムスロットをランダムアクセスバケット伝送タイムスロットとして設定した場合 ($k_2 = n$) のチャンネル構成の一例を示している。

【0087】図15では、全サブキャリアのタイムスロットTS1が、ランダムアクセスバケット伝送タイムスロットとして、割り当てられている。

【0088】図16は、一部のサブキャリアにおいて、毎フレームごとに発生するタイムスロットTS1のタイムスロットをランダムアクセスバケット伝送タイムスロットとして設定した場合 ($k_2 < n$) のチャンネル構成の一例を示している。 k_2 個のタイムスロットの選び方は、サブキャリアを連続的に割り当てても、離散的に割り当ててもよい。

【0089】図16では、サブキャリア f_3 のタイムスロットTS1は、ランダムアクセスバケット伝送タイムスロットとして、割り当てられていない。

【0090】図17は、一つのサブキャリアの全タイムスロットをランダムアクセスバケット伝送タイムスロットとして設定した場合 ($k_2 = F$) のチャンネル構成の一例を示している。

【0091】図17では、サブキャリア f_1 の全タイムスロットが、ランダムアクセスバケット伝送タイムスロットとして、割り当てられている。

【0092】図18は、一つのサブキャリアの一部のタイムスロットをランダムアクセスバケット伝送タイムスロットとして設定した場合 ($k_2 < F$) のチャンネル構成の一例を示している。

【0093】図18では、サブキャリア f_1 のタイムスロットTS1、タイムスロットTS2、タイムスロットTS4等が、ランダムアクセスバケット伝送タイムスロットとして、割り当てられている。

【0094】 k_2 個のタイムスロットの選び方は、タイムスロットを連続的に割り当てても、離散的に割り当ててもよい。

(ランダムアクセスバケット伝送タイムスロット数及び拡散符号数等の変更) 移動局からの所定期間内におけるランダムアクセスバケット数が多いと、通信できないこ

とが生じる。そこで、所定期間内におけるランダムアクセスバケット数に応じて、ランダムアクセスバケット伝送タイムスロット数及び拡散符号数等を変更する。

【0095】図19の場合は、移動局からの所定期間内におけるランダムアクセスバケット数に応じて、基地局がランダムアクセスバケット伝送タイムスロットの個数 k_2 (k_2 : 自然数、 $k_2 \leq F \times n$) を変更する際の、基地局で行われる制御の一例を示した図である。

【0096】基地局は、移動局から伝送されたランダムアクセスバケット数を、一定時間測定する (S230)。

【0097】測定した結果、ランダムアクセスバケット数があるしきい値以上の場合 (S231: YES) は、ランダムアクセスバケット伝送スロット数を増加させ、そのタイムスロットの位置を移動局に通知する (S233)。

【0098】また、測定した結果、ランダムアクセスバケット数があるしきい値以下の場合 (S232: YES) は、ランダムアクセスバケット伝送スロット数を減少させ、そのタイムスロットの位置を移動局に通知する (S234)。

【0099】ランダムアクセスバケット数があるしきい値以上でなく (S231: NO)、かつ、ランダムアクセスバケット数があるしきい値以下でない (S232: NO) 場合は、ランダムアクセスバケット伝送スロット数は変更しない。

【0100】移動局は、基地局から通知されたランダムアクセスバケット伝送タイムスロットの位置にしたがって、ランダムアクセスバケットを伝送する。

【0101】図20は、移動局からの所定期間内におけるランダムアクセスバケット数に応じて、基地局がランダムアクセスバケット伝送用の拡散符号の個数 m_2 (m_2 : 自然数、 $m_2 \leq$ 使用できる拡散符号の総数) を変更する際の、基地局で行われる制御の一例を示した図である。

【0102】基地局は、移動局から伝送されたランダムアクセスバケット数を、一定時間測定する (S240)。

【0103】測定した結果、ランダムアクセスバケット数があるしきい値以上の場合 (S241: YES) は、ランダムアクセスバケットを拡散する拡散符号数 m_2 を増加させ、その種類を移動局に通知する (S243)。

【0104】また、測定した結果、ランダムアクセスバケット数があるしきい値以下の場合 (S242: YES) は、ランダムアクセスバケットを拡散する拡散符号数 m_2 を減少させ、その種類を移動局に通知する (S244)。

【0105】ランダムアクセスバケット数があるしきい値以上でなく (S241: NO)、かつ、ランダムアクセスバケット数があるしきい値以下でない (S242:

NO) 場合は、ランダムアクセスパケットを拡散する拡散符号数は変更しない。

【0106】移動局は、基地局から通知されたランダムアクセスパケット伝送用の拡散符号の中から1つを選択して、ランダムアクセスパケットを拡散して伝送する。

【0107】図21は、移動局からの所定期間におけるランダムアクセスパケット数に応じて、基地局が前記ランダムアクセスパケット伝送タイムスロットの個数 k_2 (k_2 : 自然数、 $k_2 \leq F \times n$) 及びランダムアクセスパケット伝送用の拡散符号の個数 m_2 (m_2 : 自然数、 $m_2 \leq$ 使用できる拡散符号の総数) を変更する際の基地局で行われる制御の一例を示した図である。

【0108】基地局は、移動局から伝送されたランダムアクセスパケット数を、一定時間測定する(S250)。

【0109】測定した結果、ランダムアクセスパケット数があるしきい値以上の場合(S251: YES) は、「ランダムアクセスパケットを拡散する拡散符号数 m_2 を増加」あるいは「ランダムアクセスパケット伝送スロット数 k_2 を増加」あるいは「その双方を増加」させ、その情報を移動局に通知する(S253)。

【0110】また、測定した結果、ランダムアクセスパケット数があるしきい値以下の場合(S252: YES) は、「ランダムアクセスパケットを拡散する拡散符号数 m_2 を減少」あるいは「ランダムアクセスパケット伝送スロット数 k_2 を減少」あるいは「その双方を減少」させ、その情報を移動局に通知する(S254) ランダムアクセスパケット数があるしきい値以上でなく(S251: NO)、かつ、ランダムアクセスパケット数があるしきい値以下でない(S252: NO) 場合は、「ランダムアクセスパケットを拡散する拡散符号数」及び「ランダムアクセスパケット伝送スロット数」は変更しない。

【0111】移動局は、基地局から通知されたランダムアクセスパケット伝送タイムスロットの位置、及びランダムアクセスパケット伝送用の拡散符号の中から1つを選択して、ランダムアクセスパケットを拡散して伝送する。

【0112】図22は、ランダムアクセスパケット数が多くなると、ランダムアクセスパケットの伝送が、的確に伝送されない恐れがあることから、基地局が移動局にランダムアクセスパケットの伝送を制限(例えば、伝送を時間的に制限する。)し、移動局がその制限にしたがってランダムアクセスパケットを伝送する場合の基地局で行われる制御の一例を示した図である。

【0113】基地局は、移動局から伝送されたランダムアクセスパケット数を、一定時間測定する(S260)。

【0114】測定した結果、ランダムアクセスパケット数があるしきい値以上の場合(S261: YES) は、

ランダムアクセスパケットの伝送制限を現状よりも厳しくし、移動局に通知する(S263)。

【0115】また、測定した結果、ランダムアクセスパケット数があるしきい値以下の場合(S262: YES) には、ランダムアクセスパケットの伝送制限を現状よりも緩やかにし、移動局に通知する(S264)。

【0116】ランダムアクセスパケット数があるしきい値以上でなく(S261: NO)、かつ、ランダムアクセスパケット数があるしきい値以下でない(S262: NO) 場合は、伝送制限の変更を行わない。

(伝送量に応じた伝送速度の変更) 本発明では、移動局が伝送するパケットの伝送量の大きさに応じて、移動局の伝送速度を変更する。以下に、伝送量に応じた伝送速度の変更の様態を示す。

【0117】図23では一例として、移動局2の伝送速度に対して、移動局1が p 個の拡散符号を用いてパケットを多重化して伝送することにより p 倍の伝送速度を実現する様子を示している。

【0118】図24は、通信チャネルの一つのタイムスロットTS内で、移動局の伝送量の大きさに応じて、基地局が移動局に異なる拡散率の拡散符号を割り当てることにより、可変伝送速度を実現する一例を示した図である。

【0119】図24では、移動局2のパケットに用いられる拡散符号に対して、拡散率が $1/SF$ 倍の拡散符号により移動局1のパケットを拡散し、移動局1の伝送速度を移動局2と比較して SF 倍(チップレートは一定)にする様子を示している。

【0120】図25は、通信チャネルの一フレーム内で、移動局の伝送量の大きさに応じて、基地局が移動局に任意の q 個(q : 自然数、 $q \leq F \times n$)のタイムスロットを割り当てることにより、可変伝送速度を実現する一例を示した図である。

【0121】図26、図27、図28、図29は、移動局の伝送量の大きさに応じて、基地局は、拡散符号数 p 、異なる拡散率の拡散符号、タイムスロット数 q の内、少なくとも2つを変更して割り当てる実施の形態を説明するための図である。

【0122】図26では、図24に対して、さらに、移動局1に移動局2の拡散符号の拡散率に対して $1/SF$ 倍の拡散率を持つ p 個の拡散符号を割り当てることにより、移動局1の伝送速度を移動局2に対して $p \times SF$ 倍に設定している。

【0123】図27では、図25に対して、さらに、移動局1の各タイムスロットに p 個の拡散符号を割り当てることにより、移動局1の伝送速度を移動局2に対して $p \times q$ 倍に設定している。

【0124】図28では、一例として、移動局1に移動局2の拡散符号の拡散率に対して $1/SF$ 倍の拡散率を持つ拡散符号を割り当て、さらに q 倍のタイムスロット

を割り当てることにより、移動局1の伝送速度を移動局2に対して $q \times SF$ 倍に設定している。

【0125】図29では、一例として、移動局1に移動局2の q 倍のタイムスロットを割り当て、さらに、移動局1の各タイムスロットに移動局2の拡散符号の拡散率に対して $1/SF$ 倍の拡散率を持つ p 個の拡散符号を割り当てることにより、移動局1の伝送速度を移動局2に対して $p \times q \times SF$ 倍に設定している

【発明の効果】本発明のマルチキャリア/DS-SS-CDMAでのパケット伝送方式を用いれば、タイムスロット予約型のパケット伝送、ランダムアクセス型のパケット伝送、可変伝送速度のパケット伝送を実現することが可能となり、多様な伝送量の信号を効率的に伝送することが実現できる。

【図面の簡単な説明】

【図1】マルチキャリア/DS-SS-CDMA方式における移動局と基地局間のチャネル構成の一例を示す図である。

【図2】移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図(その1)である。

【図3】移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図(その2)である。

【図4】移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図(その3)である。

【図5】予約要求パケット伝送スロットの割り当てを説明するための図(その1)である。

【図6】予約要求パケット伝送スロットの割り当てを説明するための図(その2)である。

【図7】予約要求パケット伝送スロットの割り当てを説明するための図(その3)である。

【図8】予約要求パケット伝送スロットの割り当てを説明するための図(その4)である。

【図9】予約要求パケット伝送スロットの割り当てを説明するための図(その5)である。

【図10】予約要求パケット伝送用のタイムスロット数の変更を説明するための図である。

【図11】予約要求パケット伝送用の拡散符号数の変更を説明するための図である。

【図12】予約要求パケット伝送用のタイムスロット数及び拡散符号数の変更を説明するための図である。

【図13】予約要求パケットの伝送制限を説明するための図である。

【図14】ランダムアクセスパケット伝送スロットの割り当てを説明するための図(その1)である。

【図15】ランダムアクセスパケット伝送スロットの割り当てを説明するための図(その2)である。

【図16】ランダムアクセスパケット伝送スロットの割り当てを説明するための図(その3)である。

【図17】ランダムアクセスパケット伝送スロットの割り当てを説明するための図(その4)である。

【図18】ランダムアクセスパケット伝送スロットの割り当てを説明するための図(その5)である。

【図19】ランダムアクセスパケット伝送用のタイムスロット数の変更を説明するための図である。

【図20】ランダムアクセスパケット伝送用の拡散符号数の変更を説明するための図である。

【図21】ランダムアクセスパケット伝送用のタイムスロット数及び拡散符号数の変更を説明するための図である。

【図22】ランダムアクセスパケットの伝送制限を説明するための図である。

【図23】伝送量に応じた拡散符号の割り当てを説明するための図(その1)である。

【図24】伝送量に応じた拡散符号の割り当てを説明するための図(その2)である。

【図25】伝送量に応じたタイムスロット数の割り当てを説明するための図である。

【図26】伝送量に応じた拡散符号の割り当てを説明するための図(その3)である。

【図27】伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図(その1)である。

【図28】伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図(その2)である。

【図29】伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図(その3)である。

【符号の説明】

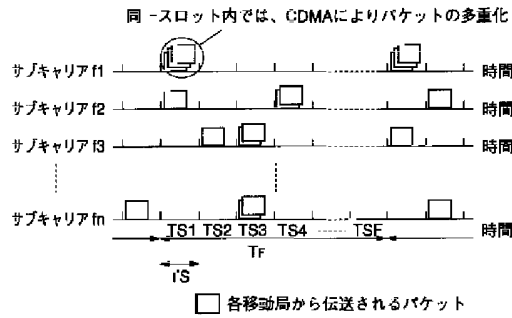
$f_1 \sim f_n$ サブキャリア

TS タイムスロット

TF フレーム長

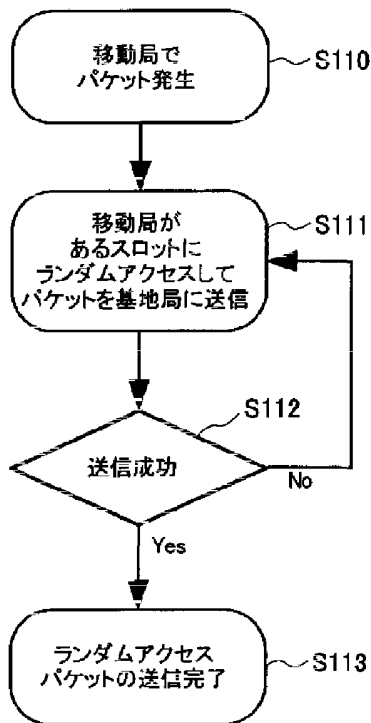
【図1】

マルチキャリア/DS-SS-CDMA方式における移動局と
基地局間のチャネル構成の一例を示す図



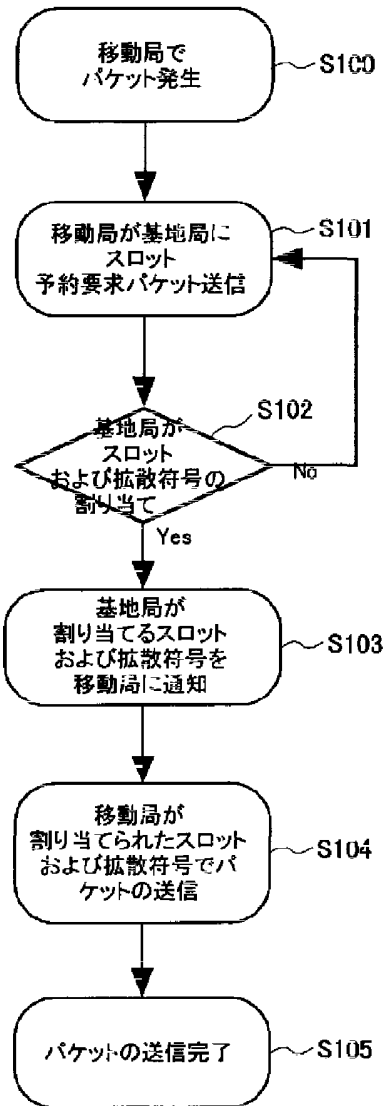
【図3】

移動局から基地局にパケット伝送する際に、移動局と基地局の
間で行われる制御のやり取りの一例を示す図 (その2)



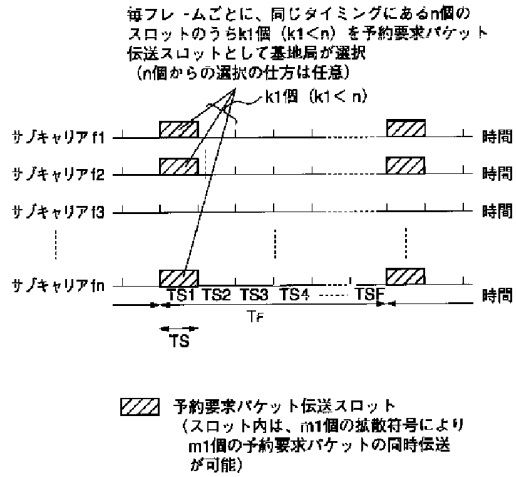
【図2】

移動局から基地局にパケット伝送する際に、移動局と基地局の間で行われる制御のやり取りの一例を示す図（その1）



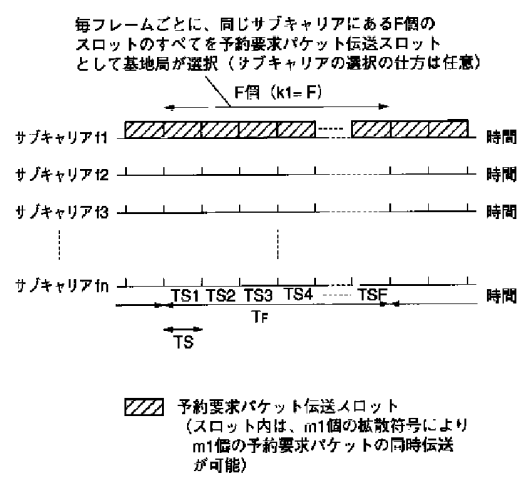
【図7】

予約要求パケット伝送スロットの割り当てを説明するための図 (その3)



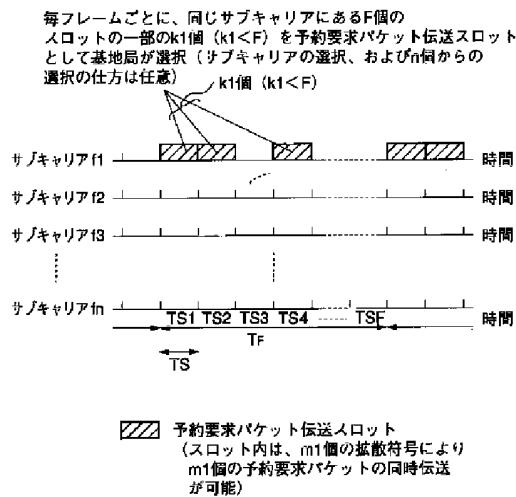
【図8】

予約要求パケット伝送スロットの割り当てを説明するための図 (その4)



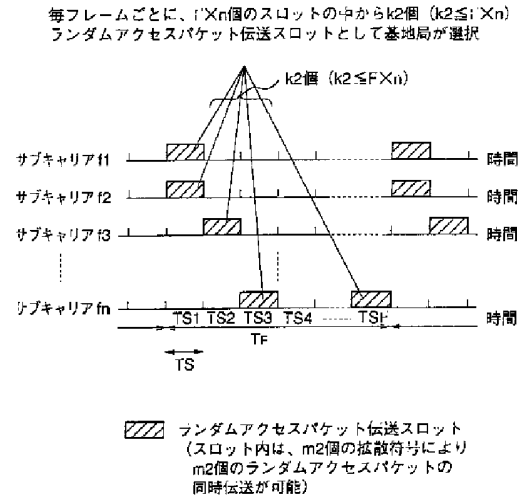
【図9】

予約要求パケット伝送スロットの割り当てを説明するための図 (その5)



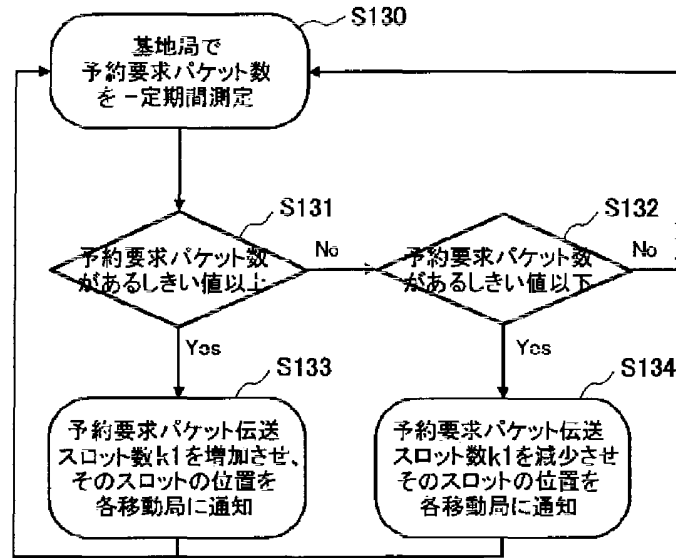
【図14】

ランダムアクセスパケット伝送スロットの割り当てを説明するための図 (その1)



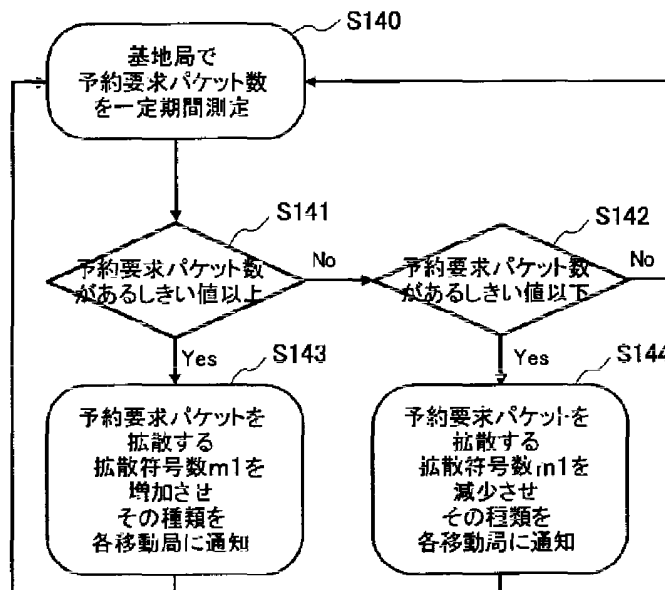
【図10】

予約要求パケット伝送用のタイムスロット数の変更を説明するための図



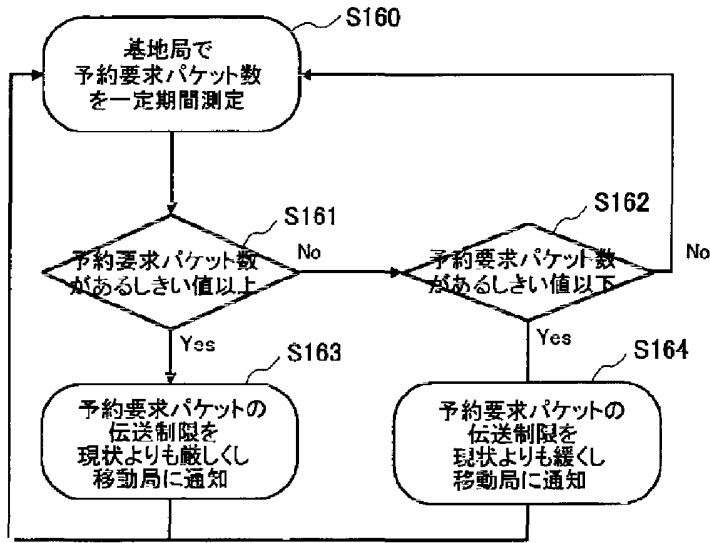
【図11】

予約要求パケット伝送用の拡散符号数の変更を説明するための図



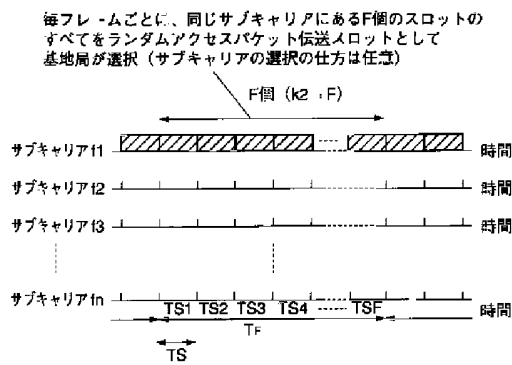
【図13】

予約要求パケットの伝送制限を説明するための図



【図17】

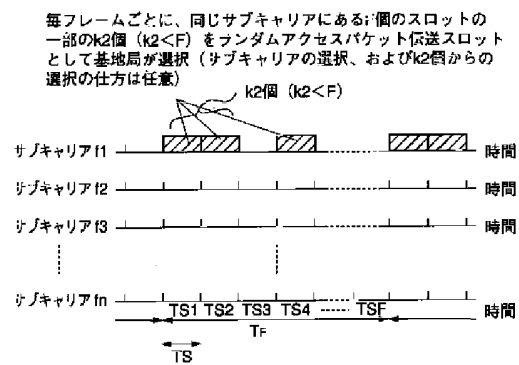
ランダムアクセスパケット伝送スロットの割り当てを説明するための図 (その4)



ランダムアクセスパケット伝送スロット (スロット内は、m2個の拡散符号によりm2個のランダムアクセスパケットの同時伝送が可能)

【図18】

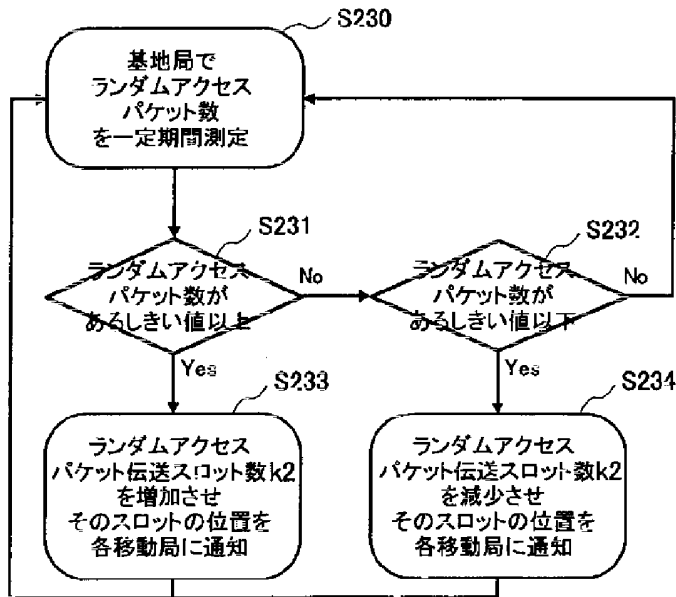
ランダムアクセスパケット伝送スロットの割り当てを説明するための図 (その5)



ランダムアクセスパケット伝送スロット (スロット内は、m2個の拡散符号によりm2個のランダムアクセスパケットの同時伝送が可能)

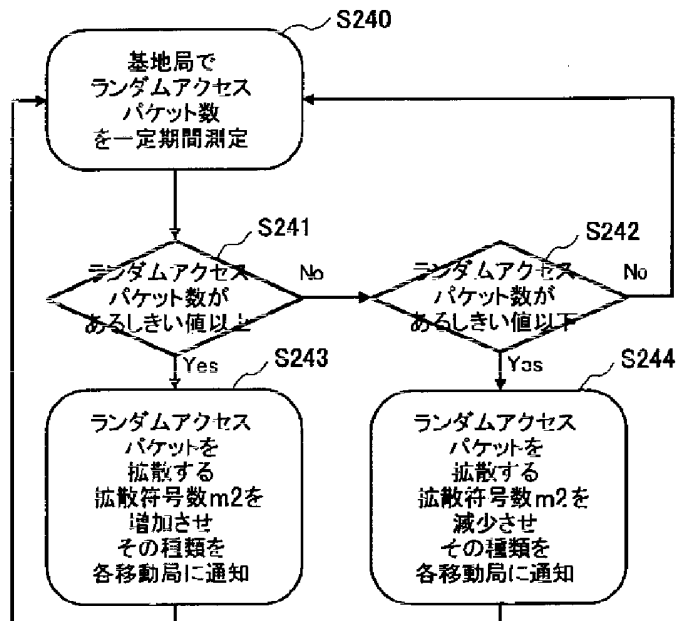
【図19】

ランダムアクセスパケット用のタイムスロット数の変更を説明するための図



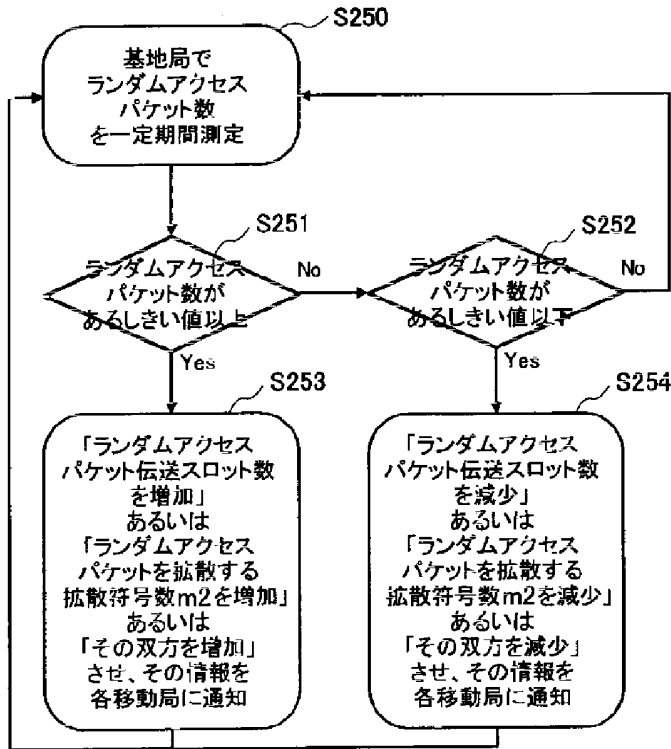
【図20】

ランダムアクセスパケット用の拡散符号数の変更を説明するための図



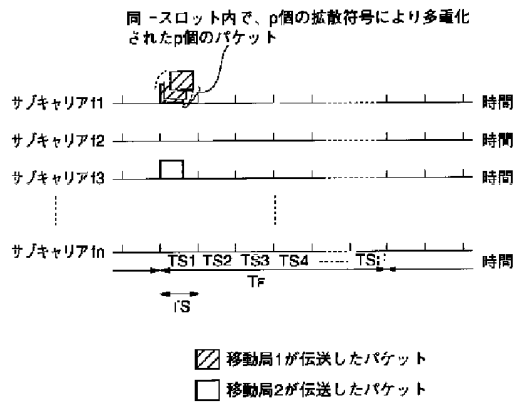
【図21】

ランダムアクセスパケット用のタイムスロット数及び拡散符号数の変更を説明するための図



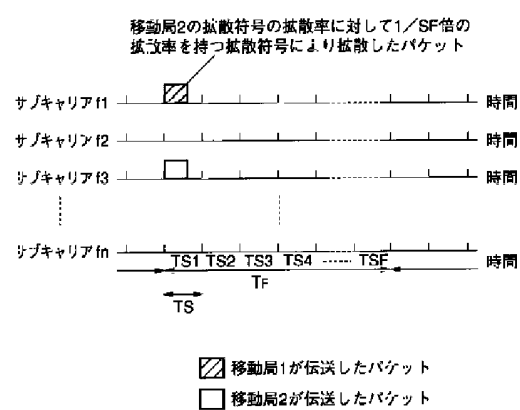
【図23】

伝送量に応じた拡散符号の割り当てを説明するための図 (その1)



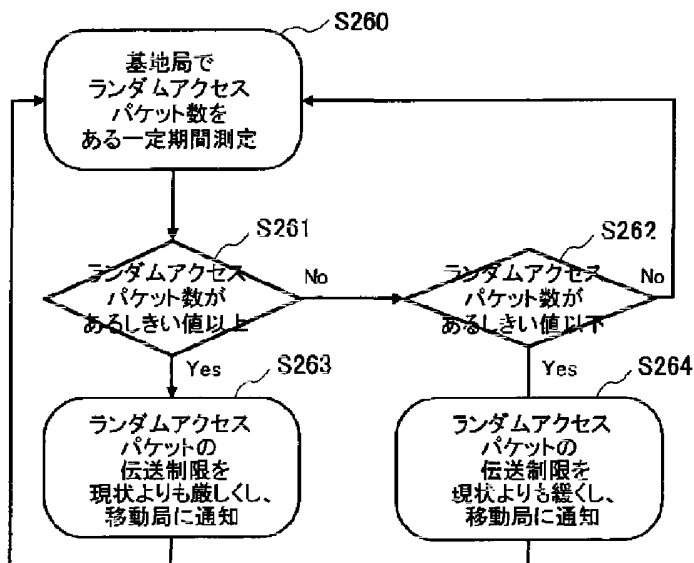
【図24】

伝送量に応じた拡散符号の割り当てを説明するための図 (その2)



【図22】

ランダムアクセスパケットの伝送制限を説明するための図



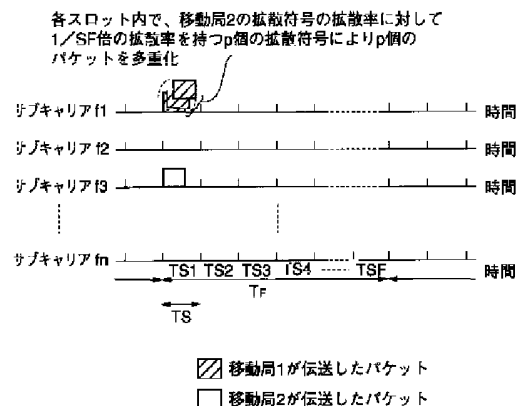
【図25】

伝送量に応じたタイムスロット数の割り当てを説明するための図 (その2)



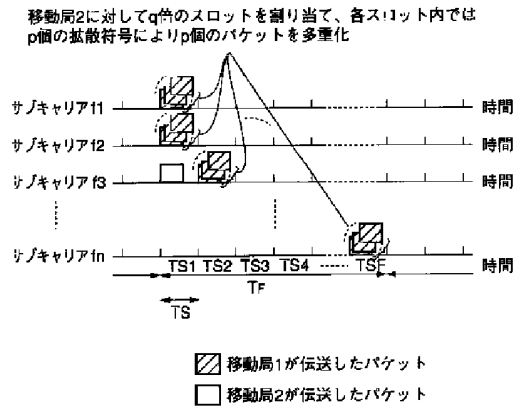
【図26】

伝送量に応じた拡散符号の割り当てを説明するための図 (その3)



【図27】

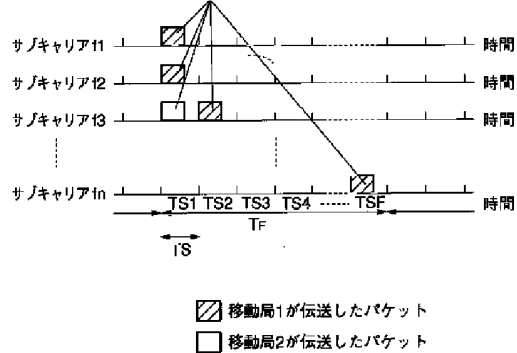
伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図(その1)



【図28】

伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図(その2)

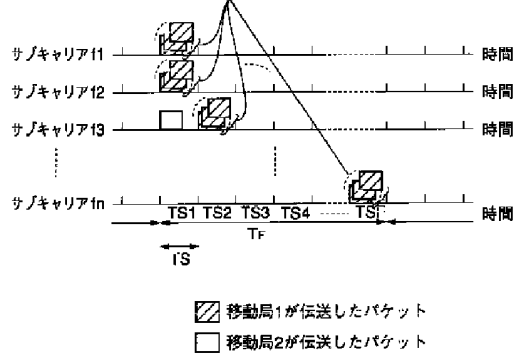
移動局2に対して q 倍のスロットを割り当て、各スロット内では移動局2の拡散符号の拡散率に対して $1/S_i$ 倍の拡散率を持つ拡散符号により拡散したバケット



【図29】

伝送量に応じたタイムスロット及び拡散符号の割り当てを説明するための図(その3)

移動局2に対して q 倍のスロットを割り当て、各スロット内では移動局2の拡散符号の拡散率に対して $1/SF$ 倍の拡散率を持つ p 個の拡散符号により q 個のバケットを多重化



フロントページの続き

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Espacenet

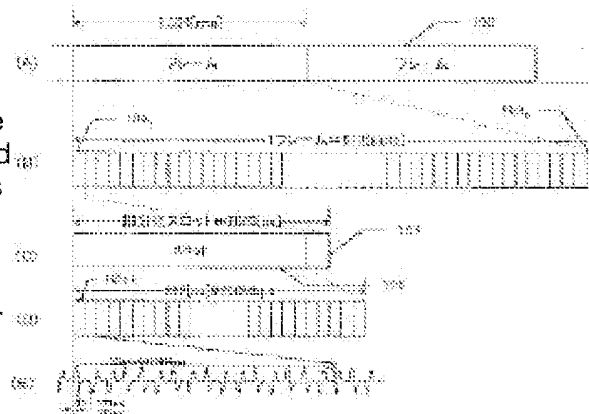
Bibliographic data: JP2003179576 (A) — 2003-06-27

RADIO COMMUNICATION SYSTEM, RADIO TRANSMISSION EQUIPMENT, RADIO RECEPTION EQUIPMENT, RADIO TRANSMISSION METHOD, RADIO RECEPTION METHOD, ITS PROGRAM AND PROGRAM RECORDING MEDIUM

Inventor(s): SUZUKI MITSUHIRO ±
Applicant(s): SONY CORP ±
Classification: - **international:** H04J13/00; H04L7/00; (IPC1-7): H04J13/00; H04L7/00
 - **European:**
Application number: JP20020258743 20020904
Priority number (s): JP20020258743 20020904; JP20010290227 20010921

Abstract of JP2003179576 (A)

PROBLEM TO BE SOLVED: To provide a radio transmission system wherein data transmission is rightly enabled without receiving restriction of use of communication equipment, even if an interference due to another network is received, when at least two radio networks which are not adjusted to each other exist at positions where they receive interference mutually. ; **SOLUTION:** In an ultrawide band radio transmission system, subdivided slots 103 of frames 101, 102 are transmitted by changing the order at random by using a previously determined slot arrangement pattern, and received by returning the order of received slots to the original order by using the previously determined slot arrangement pattern. As a result, communication in the respective networks is rightly enabled when at least two unadjusted networks which obtain diversity effect to interference in an ultrawide band radio transmission system approach each other. ; **COPYRIGHT:** (C)2003,JPO



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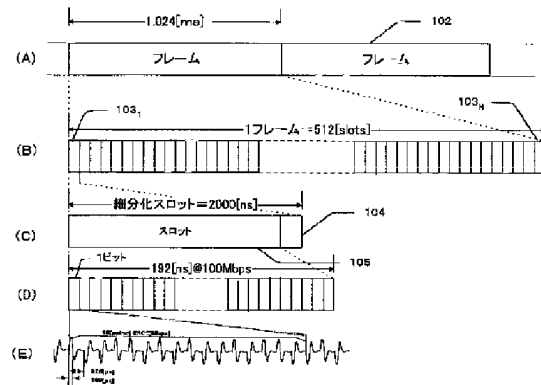
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MM14 MM32 MM33 MM35 MM36

(54) 【発明の名称】 無線通信システム、無線送信装置、無線受信装置、無線送信方法、無線受信方法、そのプログラム並びにプログラム記録媒体

(57) 【要約】

【課題】 互いに調整されていない2つ以上の無線ネットワークが相互に干渉を受ける位置に存在する場合において、通信装置の使用の制限を受けることなく、他方のネットワークの干渉を受けても正しくデータ伝送できる無線伝送方式を提供する。

【解決手段】 ウルトラワイドバンド無線伝送方式において、フレーム101、102の細分化スロット103を予め定めたスロット配列パターンを用いてランダムに順番を入れ替えて送信し、かつ該予め定めたスロット配列パターンを用いて受信したスロットの順番を元に戻して受信することにより、干渉に対するダイバーシティ効果を得て調整されていない2以上のウルトラワイドバンド無線伝送方式によるネットワークが近接していても、それぞれのネットワークにおける通信が正しく行える。



【特許請求の範囲】

【請求項1】 二以上のネットワークが互いに調整されることなく存在し、各々のネットワークでは所定の周期を有する時分割フレームを用いて無線通信が行われる無線通信システムにおいて、

前記時分割フレームは細分化された複数の細分化スロットからなり、

各無線通信装置は、送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに応じた順番に配列し、

前記配列された細分化スロットを用いて無線通信を行うことを特徴とする無線通信システム。

【請求項2】 請求項1に記載の無線通信システムにおいて、

前記スロット配列パターンは、前記細分化スロットを前記時分割フレーム全体の領域にランダムに配列させるものであることを特徴とする、無線通信システム。

【請求項3】 請求項1に記載の無線通信システムにおいて、

基地局から割り当てられた領域に対応する前記細分化スロット数はN個であり、

前記スロット配列パターンは、前記N個の細分化スロットをJ個の連続したスロットを一つのグループとするN/J個のグループにし、各グループから細分化スロットを一つずつJ個のスロット群に割り振ることにより、各スロットの配列を行わせるものであることを特徴とする、無線通信システム。

【請求項4】 請求項1に記載の無線通信システムにおいて、

前記時分割フレームはコンテンション・ピリオドを含み、

各無線通信装置がコンテンション・ピリオドを使用して無線通信を行う場合、複数の連続した細分化スロットを送信領域として割り当てた後に、所定のスロット配列パターンに応じた順番に配列することを特徴とする、無線通信システム。

【請求項5】 請求項1に記載の無線通信システムにおいて、

前記時分割フレームには、前記スロット配列パターンの同期を獲得するための所定の同期用パターンを含む同期用スロットを複数存在することを特徴とする、無線通信システム。

【請求項6】 請求項5に記載の無線通信システムにおいて、

前記所定の同期用パターンは、同期用スロット長と同じ長さであることを特徴とする、無線通信システム。

【請求項7】 請求項5に記載の無線通信システムにおいて、

前記所定の同期用パターンは同期用スロット長よりも短く、該同期用パターンの繰り返しを用いて、前記同期用

スロットを構成することを特徴とする、無線通信システム。

【請求項8】 請求項5に記載の無線通信システムにおいて、

同期用スロット長が同期パターンの長さの整数倍でなく、

繰り返して生成される同期用パターンに同期用スロットを窓としてかけて取り出した窓同期ワードを同期用スロットとして伝送することを特徴とする、無線通信システム。

【請求項9】 二以上のネットワークが互いに調整されることなく存する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線送信装置であって、

前記時分割フレームは細分化された複数の細分化スロットからなり、

送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するよう制御するスロット配列制御手段と、

前記スロット配列制御手段の制御により細分化スロットの配列を行うスロット配列手段と、

前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信させるように送信手段を制御する送信タイミング制御手段と前記スロット配列手段から配列された細分化スロットを受け取り、これを前記送信タイミング制御手段により制御されたタイミングで無線通信する送信手段と、を有することを特徴とする、無線送信装置。

【請求項10】 請求項9に記載の無線送信装置において、

前記スロット配列パターンは、前記細分化スロットを前記時分割フレーム全体の領域にランダムに配列させるものであることを特徴とする、無線送信装置。

【請求項11】 請求項9に記載の無線送信装置において、

基地局から割り当てられた前記領域に対応する細分化スロット数はN個であり、

前記スロット配列パターンは、N個の細分化スロットを、J個の連続した細分化スロットを一つのグループとするN/J個のグループにし、各グループから細分化スロットを一つずつJ個のスロット群に割り振ることにより、細分化スロットの配列を行うことを特徴とする、無線送信装置。

【請求項12】 請求項9に記載の無線送信装置において、

前記時分割フレームには、前記スロット配列パターンの同期を獲得するための所定の同期用パターンを含む同期用スロットが複数存在することを特徴とする、無線送信装置。

【請求項13】 二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う無線受信装置であって、

無線送信装置から無線信号を受信し、これを復調するための受信手段と、

前記無線送信装置が用いたスロット配列パターンを用いて所定のタイミングで受信信号の内必要なスロットに対応する部分を復調するように前記受信手段を制御する受信タイミング制御手段と、

前記スロット配列パターンに従って配列するよう制御するスロット配列制御手段と、

前記受信手段から復調された受信信号の内必要なスロットに対応する部分を受け取り、これを前記スロット配列制御手段の制御に従って配列するスロット配列手段とを有することを特徴とする、無線受信装置。

【請求項14】 請求項13に記載の無線受信装置において、

前記スロット配列パターンの同期を獲得するため、所定の同期用パターンを検出する相関検出手段をさらに備えることを特徴とする、無線受信装置。

【請求項15】 請求項13に記載の無線受信装置において、

この無線受信装置は、前記スロット配列手段により配列された受信データについて誤り訂正を行う誤り訂正手段をさらに有することを特徴とする、無線受信装置。

【請求項16】 二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う無線送信方法であって、

前記時分割フレームは細分化された複数の細分化スロットからなり、

送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するステップと、

前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信する送信ステップと、を有することを特徴とする、無線送信方法。

【請求項17】 請求項16に記載の無線送信方法において、

前記スロット配列パターンは、前記細分化スロットを前記時分割フレーム全体の領域にランダムに配列させるものであることを特徴とする、無線送信方法。

【請求項18】 請求項16に記載の無線送信方法において、

基地局から割り当てられた領域に対応する前記細分化スロット数はNスロットであり、

前記スロット配列パターンは、前記N個の細分化スロットをJ個の連続したスロットを一つのグループとするN/J個のグループにし、各グループから細分化スロット

を一つずつJ個のスロット群に割り振ることにより、各スロットの配列を行うことを特徴とする、無線送信方法。

【請求項19】 二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線受信方法であって、

無線信号を所定のスロット配列パターンに応じたタイミングで受信するステップと、

送信装置が用いたスロット配列パターンに従ってスロットを配列するステップと、を有することを特徴とする無線受信方法。

【請求項20】 請求項19に記載の無線受信方法において、

前記スロット配列パターンの同期を獲得するため、所定の同期用パターンを検出する相関検出ステップをさらに備えることを特徴とする、無線受信方法。

【請求項21】 二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを複数の細分化スロットに細分化して無線通信を行う、演算装置を有する無線送信装置において、この演算装置を：送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するよう制御するスロット配列制御手段と、

前記スロット配列制御手段の制御により細分化スロットの配列を行うスロット配列手段と、前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信させるように送信制御する送信タイミング制御手段ととして機能させるためのプログラム。

【請求項22】 二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う、演算装置を有する無線受信装置において、この演算装置を：無線送信装置が用いたスロット配列パターンを用いて所定のタイミングで受信信号の内必要なスロットに対応する部分を復調するように無線信号の受信を制御する受信タイミング制御手段と、

前記スロット配列パターンに従って配列するよう制御するスロット配列制御手段と、前記受信手段から復調された受信信号の内必要なスロットに対応する部分を受け取り、これを前記スロット配列制御手段の制御に従って配列するスロット配列手段ととして機能させる、プログラム。

【請求項23】 二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを複数の細分化スロットに細分化して通信を行う無線送信方法を演算装置に実行させるプログラムにおいて、

送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するステップと、

前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信する送信ステップと、を演算装置に実行させることを特徴とするプログラム。

【請求項24】 二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線受信方法を演算装置に実行させるためのプログラムにおいて、無線信号を所定のスロット配列パターンに応じたタイミングで受信させるステップと、送信装置が用いたスロット配列パターンに従ってスロットを配列するステップとを演算装置に実行させることを特徴とするプログラム。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、無線通信システム、無線送信装置、無線受信装置、無線送信方法、無線受信方法、そのプログラム並びにプログラム記録媒体に関する。

【0002】

【従来の技術】近年の情報化によりLAN (Local Area Network) の普及に伴い、オフィス内の配線工事、工事期間の短縮、室内美観上の課題、保守運用管理の複雑などの問題から無線LANへの要求が高まっている。かかる無線LANに用いられる無線伝送方式としてウルトラワイドバンド (Ultra Wide Band: UWB) 無線伝送方式がある。

【0003】ウルトラワイドバンド無線伝送方式は、基本的には、非常に細かいパルス幅 (例えば1 ns (ナノ秒) 以下) のパルス列からなる信号を用いて、ベースバンド伝送を行なうものである。このUWB無線伝送方式は、所定の無線信号に例えば送信する情報に所定の拡散符号系列を掛け合わせて拡散情報を形成する。さらに、数百ナノ秒の周期で一つの短いインパルスを発生させ、そのインパルス位相あるいは時間変化を、前述の拡散情報にあわせて変化させた信号を送信信号として利用し、一方情報を受信する装置は、前記送信されたインパルスの位相あるいは微妙な時間変化によってインパルス信号の情報ビットを識別し、これに所定の拡散符号系列を用いて逆拡散することによって、所望の情報ビットを得るというものである。また、その占有帯域幅は、占有帯域幅をその中心周波数 (例えば1 GHzから10 GHz) で割った値がほぼ1となるようなGHzオーダーの帯域幅であり、所謂W-CDMA方式やcdma2000方式、並びにSS (Spread Spectrum) やOFDM (Orthogonal Frequency Division Multiplexing) を用いた無線LANで使用される帯域幅に比べて、超広帯域

なものとなっている。

【0004】また、ウルトラワイドバンド伝送方式は、その低い信号電力密度の特性により、特定の周波数帯域に高い信号電力密度特性を持つ既存の無線システムに対し干渉を与えにくい特徴を有しており、既存の無線システムが利用している周波数帯域にオーバーレイ可能な技術として期待されている。さらに広帯域であることからパーソナルエリアネットワーク (Personal Area Network: PAN) の用途で、100Mbpsレベルの超高速無線伝送技術として有望視されている。

【0005】一方で、UWB無線伝送では、互いに調整されていない (uncoordinated) な2つ以上のUWB無線ネットワークが同一エリアにある場合を想定すると、各送受信機の位置関係によっては大きな干渉を与えることも想定される。この場合、UWB無線伝送では超広帯域な占有帯域を用いているため、回避するための周波数チャンネルがなく、最悪の場合通信ができなくなってしまうといった懸念がある。ここで「互いに調整されていない (uncoordinated)」とは、個々のネットワークを制御する制御局間でチャンネル割当情報などを共有しないことをいう。

【0006】この問題を解決する手段の一つとして、1つのチャンネルをフレームに分割し、フレーム毎にリソースの割り当てを行う時分割多元接続 (Time Division Multiple Access) TDMA方式が用いられている。

【0007】

【発明が解決しようとする課題】時分割多元接続方式では、ネットワーク中の1通信に対して、フレーム内の比較的長い時間にわたって連続的なリソースの割り当てをする。

【0008】従来のTDMA方式では、以下のようなフレーム構成を採用する。図13にフレーム構成例を示す。

【0009】TDMAでは、図13(A)に示すように、例えばTDMAの単位フレーム (「TDMAフレーム」という) 1301, 1302, 1303が繰り返されている。このTDMAフレームの長さは、例えば1マイクロ秒である。

【0010】このTDMAフレームのそれぞれにおいては、図13(B)に示すように、フレーム先頭に、無線リソースの割り当て情報 (リソースアサイン情報) を含む識別信号であるビーコン1304が配置され、そのビーコン1304に続けて、該無線ネットワークに含まれる端末局 (もしくはユーザ) 宛ての領域が割り当てられる。図13(B)に示す例では、ビーコン1304の後に、端末局A、端末局B、端末局Cの順に割り当てられた領域 (「ユーザ割当領域」という) 1305, 1306, 1307が設定されている。各端末局に割り当てられた領域は、フレームごとに可変であってもよい。

【0011】また、ビーコン1304、各ユーザ割当領

域1305, 1306, 1307以外の領域には、コンテンション・ピリオド1308が設定されている。コンテンション・ピリオド (Contention Period) は、端末局から基地局へのランダムアクセスチャネルや、端末局間の通信用に使用される領域である。このコンテンション・ピリオドでは、基地局により割り当てられた区間ではないので、ネットワーク内通信の衝突 (Contention) が生じ得る。

【0012】このようなTDMAフレームを用いた通信では、例えば、端末局からは、コンテンション・ピリオドにおいてランダムアクセスチャネル (RACH) で次のフレームでのリソース割り当てを要求 (送信要求) し、基地局はその要求に応じて次のフレームにおけるリソース割り当てのためにユーザ割当領域を定め、これを次のフレームのビーコン1309によって各端末局に報知する。そして、各端末局は、該ビーコンのリソース割り当て情報に基づいて通信を行う。

【0013】上述のようなTDMAフレームを用いた通信を行う互いに調整されていない (Uncoordinate) 2つ以上のUWBネットワークが近接して配置されていると、ネットワーク内の局に対する干渉が連続的に起こりやすく、その場合、干渉を受けた局においてエラー訂正などではデータが復帰できず、通信ができなくなってしまうという問題点がある。

【0014】図14に、2つのネットワークが近接して配置されている図を示す。図のようにパーソナル・エリア・ネットワーク (Personal Area Network; 以下PANという) X1401とPANY1402が互いに調整されていない状態で近接して配されている。PANX1401は、基地局X1403と、該基地局X1403によって制御される端末局A1405、端末局B1406、端末局C1407、および端末局F1410とにより構成される。一方、PANY1402は、基地局Y1404と、該基地局Y1404によって制御される端末局D1408および端末局E1409とにより構成されている。

【0015】また、端末局C1407と端末局E1409は、一方が無線送信をした場合に他方の受信する無線信号に干渉するような位置関係にあるものとする。

【0016】図15に、上述のPANX1401とPANY1402のフレーム状態を示す。図15(A)はある時点におけるPANX1401のフレームの状態を表し、図13(B)は、同時点でのPANY1402のフレームの状態を表している。

【0017】図に示すように、端末局F (端末局F1410から端末局C1407への通信とする) に割り当てられたユーザ割当領域1501と端末局E1207の送信に割り当てられたユーザ割当領域1302とは、時間的に重複した状態となっている。この図のように、互いの位置が近いパーソナル・エリア・ネットワークXに属

する端末局Cと、別のパーソナル・エリア・ネットワークYに属する端末局Eが割り当てられたユーザ割当領域が衝突している場合は、通信が出来なくなるおそれが生ずる。

【0018】したがって、上記のような状況にならないようにするためには、各ネットワークを構成する通信装置を使用する上で、何らかの制限を設ける必要があった。例えば、互いに調整されていない2つ以上のネットワークが同一エリアに存在しないようにする必要があった。

【0019】本発明の目的は、互いに調整されていない2つ以上の無線ネットワークが相互に干渉を受ける位置に存在する場合においても、通信装置の使用の制限を受けることなく、他方のネットワークの干渉を受けても正しくデータ伝送できる無線伝送方式を提供することにある。

【0020】

【課題を解決するための手段】上記の課題を解決する手段として、本発明は以下の特徴を有する。本発明の第1の態様は、二以上のネットワークが互いに調整されることなく存在し、各々のネットワークでは所定の周期を有する時分割フレームを用いて無線通信が行われる無線通信システムとして提案される。この無線通信システムでは、時分割フレームは細分化されて、複数の細分化スロットとして扱われる。この無線通信システムを構成する各無線通信装置は、送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに応じて、順番に配列し、この配列後の細分化スロットを用いて無線通信を行う。

【0021】本発明の第2の態様は、二以上のネットワークが互いに調整されることなく存する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線送信装置として提供される。この無線送信装置は、前記時分割フレームを複数の細分化スロットに細分化して扱う。この無線送信装置は、送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するよう制御するスロット配列制御手段と、前記スロット配列制御手段の制御により細分化スロットの配列を行うスロット配列手段と、前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信させるように送信手段を制御する送信タイミング制御手段と、前記スロット配列手段から配列された細分化スロットを受け取り、これを前記送信タイミング制御手段により制御されたタイミングで無線通信する送信手段とを有することを特徴としている。

【0022】本発明の第3の態様は、二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う無線受信装置として提供される。この無線受信装置は、

無線送信装置から無線信号を受信し、これを復調するための受信手段と、前記無線送信装置が用いたスロット配列パターンを用いて所定のタイミングで受信信号の内必要なスロットに対応する部分を復調するように前記受信手段を制御する受信タイミング制御手段と、前記スロット配列パターンに従って配列するよう制御するスロット配列制御手段と、前記受信手段から復調された受信信号の内必要なスロットに対応する部分を受け取り、これを前記スロット配列制御手段の制御に従って配列するスロット配列手段とを有することを特徴としている。

【0023】本発明の第4の態様は、二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して通信を行う無線送信方法として提供する。この無線送信方法において、時分割フレームは複数の細分化スロット二分割されて扱われる。この無線送信方法は、送信を行うために基地局から割り当てられた領域に対応する前記細分化スロットを、所定のスロット配列パターンに従って配列するステップと、前記所定のスロット配列パターンに従ったタイミングで、前記配列された細分化スロットを送信する送信ステップとを有することを特徴としている。

【0024】本発明の第5の態様は、二以上のネットワークが互いに調整されることなく存在する環境の下、所定の周期を有する時分割フレームを使用して無線通信を行う無線受信方法として成立する。本無線受信方法は、無線信号を所定のスロット配列パターンに応じたタイミングで受信するステップと、送信装置が用いたスロット配列パターンに従ってスロットを配列するステップとを有することを特徴としている。

【0025】

【発明の実施の形態】次に、本発明の実施の形態について、図面を参照しながら説明する。

【0026】〔本実施の形態にかかるフレームの構成例〕まず、本実施の形態において使用されるフレームの構成例について説明する。

【0027】図1(A)は、所定の長さを有するフレーム101、102、…が繰り返されるようになっている。例えば、図示の例では、1のフレームは1024[ms]とする。

【0028】この1つのフレームはN個の細分化スロット1031~103N(以下、総称的に「細分化スロット103」と呼ぶ)で構成される。図1(B)に示す例では、1のフレームは512個の細分化スロット103から成り、この場合各細分化スロット103のスロット長は、1024[ms]/512=2000[ns]となる。

【0029】次に細分化スロット103の構成について説明する。図1(C)は、本実施の形態にかかる細分化スロット103の構成例を示す。細分化スロット103のうちの一部は、ガード・ピリオド(guard period)10

4として、送信信号を含めない領域とする。ガード・ピリオド104は、連続する細分化スロット103が異なる送信装置により使用されている場合、各細分化スロットにおいて送信された送信信号が異なる伝搬遅延の後ある受信機に到達したとしても、送信信号を衝突させないために設けられている。

【0030】該ガード・ピリオド104を除いた、細分化スロットの残りの領域105は、送信信号を含む領域である。図1に示す例では、ガード・ピリオドの長さは80[ns]、領域105の長さは1920[ns]である。

【0031】この領域105には情報ビットが含まれる。たとえば送信速度が100[Mbps]のときは100[Mbps]×1920[ns]=192[bit]が1スロット内に含まれることになる。

【0032】特に従来例に示したUWB伝送方式では、この1ビットは16個のパルス(パルス幅は100[ps])によって表されている。図1(E)に示す例では、直接拡散コードの0または1にしたがいパルスの位相を反転させるBi-phase変調で変調されて構成されるパルス列がパルス間隔625[ps]おきに伝送されている。

【0033】なお、上記説明では、一例として具体的数値を上げて説明したが、本発明はかかる数値に限定される趣旨ではない。また、UWB伝送方式の変調方式は、パルス生成タイミングを微妙にずらした信号を用いる、いわゆるパルス位置変調であっても良い。

【0034】〔無線送信装置、無線受信装置の構成例〕次に、上記の複数のスロットからなるフレームを用いた無線伝送方式を行うための、無線送信装置と無線受信装置の構成例について説明する。

【0035】図2は、本実施の形態にかかる無線送信装置の構成例を示すブロック図である。送信装置は、符号化及びインターリーブ手段201と、スロット配列手段202と、送信タイミング制御手段203と、送信手段204と、アンテナ205と、スロット配列制御手段206とを有している。なお實際上、符号化及びインターリーブ手段201と、スロット配列手段202、送信タイミング制御手段203、及びスロット配列制御手段206は、中央演算装置(CPU)によって構成されても良く、該CPUは図示しない記憶装置(例えば、EEPROM(Electrically Erasable Programmable Read-Only Memory)など)に格納されたプログラムにしたがって、以下に述べるような処理を実行する。

【0036】符号化及びインターリーブ手段(以下、「符号化手段」と略す)201は、送信すべき情報の提供先から情報データを受け取り、これを誤り訂正符号を用いて符号化し、バースト誤りをランダム誤りに置換して畳み込み符号の効果を引き出すようにインターリーブして得られる符号化データをスロット配列手段202に渡すように動作する。

【0037】スロット配列手段202は、送信を行うために基地局から割り当てられたチャンネル(例えば、図7(A)に示すような各端末に割り当てられた時分割スロット)に含まれる複数の細分化スロットを、スロット配列制御手段206の制御により、所定のスロット配列パターンに従って配列若しくは並び替えを行うように動作する。

【0038】今、送信しようとする情報ビットがスロット番号3, 4, 5, 6に相当するスロットにあるものとする。なお、説明の便宜上スロット番号はフレームの最初のスロットを1番、最終のスロットをN番するように連続して付されているものとする。

【0039】スロット配列制御手段206の制御により、所定の配列パターンは、スロット番号3, 4, 5, 6のスロットがそれぞれスロット番号44, 11, 79, 58に配列されるとすると、この4つのスロットに割り当てられたスロット化データは、{4(11), 3(44), 6(58), 5(79)}という順に配列される。なお、かっこ内の数字は配列された後のスロット番号を示す。

【0040】送信タイミング制御手段203は、前記所定のスロット配列パターンに従ったタイミングで、配列されたスロット化データを送信手段204に送信させるように動作する。

【0041】前述の例によれば、スロット番号4, 3, 6, 5に相当するスロット化データを、11, 44, 58, 79のタイミングで送信手段に送信させる。なお、このスロット配列方法については別途詳述する。

【0042】送信手段204は、送信タイミング制御手段203より受け取った送信タイミングで、データをUWB伝送方式により無線信号に変換して、アンテナ205より放射するように動作する。図3は、ウルトラワイドバンド伝送方式による送信手段の構成例を示すブロック図であり、図2の送信手段204、アンテナ205をより詳細に表したものである。

【0043】拡散符号生成器302は、シンセサイザ301の周波数で拡散符号系列を乗算器303に出力する。乗算器303では、スロット化データに拡散符号系列が乗算されて拡散信号となり、この拡散信号がパルス発生器304に出力される。

【0044】パルス発生器304では、拡散信号の0/1に対応して、例えば100psの非常に細かいパルス信号を発生させる。このパルス信号は、バンドパスフィルタ305に出力され、そこで不要成分が除去されて送信信号となり、アンテナ306(図2における205に相当)を介して送信される。なお、バンドパスフィルタ305は必須の構成要素ではない。

【0045】[無線受信装置の構成例]次に、本実施の形態における無線受信装置の構成例について説明する。

【0046】図4は、本実施の形態における無線受信装

置の構成例を示すブロック図である。受信装置は、アンテナ400と、受信手段401と、受信タイミング制御手段402と、スロット配列手段403と、スロット配列制御手段405と、配列パターン同期検出用相関器406と、エラー(誤り)訂正手段404とを有している。なお實際上、受信タイミング制御手段402と、スロット配列手段403と、スロット配列制御手段405と、エラー訂正手段404とは中央演算装置(CPU)によって構成されても良く、該CPUは図示しない記憶装置(例えば、EEPROM(Electrically Erasable Programmable Read-Only Memory)など)に格納されたプログラムにしたがって、以下に述べるような処理を実行することにより、受信タイミング制御手段402と、スロット配列手段403と、スロット配列制御手段405と、エラー訂正手段404として機能する。

【0047】受信手段401は、アンテナ400を介して送信装置から送信された無線信号を受信し、これを復調して受信データを出力するように動作する。図5は、ウルトラワイドバンド信号を受信する受信手段401の構成例を示すブロック図である。アンテナ400を介して受信された受信信号は、バンドパスフィルタ502で不要成分が除去された後に、乗算器507, 513, 510に出力される。なお、バンドパスフィルタ502は必須の構成要素ではない。

【0048】拡散符号生成器504は、シンセサイザ503の周波数で拡散符号系列(図5に示す送信装置で用いた拡散符号系列と同じ拡散符号系列)をパルス発生器505に出力する。パルス発生器505では、パルスを発生させると共に、拡散符号生成器504から出力された拡散符号系列をパルスに重畳して、遅延器506, 512及び乗算器510に出力する。

【0049】遅延器506では、拡散符号系列を重畳したパルスを1/2パルス幅遅延させて乗算器507に出力する。また、遅延器512では、拡散符号系列を重畳したパルスを1パルス幅遅延させて乗算器513に出力する。

【0050】したがって、乗算器507では、送信データを復調するための、拡散符号系列を重畳したパルスが受信信号に乗算され、逆拡散処理が行われる。乗算器507の乗算結果は、積分器508に出力され、積分器508で積分されて受信データとして出力される。

【0051】また、乗算器510では、遅延器506の出力より1/2パルス幅先行したタイミングで、拡散符号系列を重畳したパルスが受信信号に乗算され、逆拡散処理が行われる。また、乗算器513では、遅延器506の出力より1/2パルス幅遅延した、拡散符号系列を重畳したパルスが受信信号に乗算され、逆拡散処理が行われる。

【0052】乗算器510の乗算結果は、積分器511に出力され、積分器511で積分されて差分器515に

出力される。乗算器513の乗算結果は、積分器514に出力され、積分器514で積分されて差分器515に出力される。

【0053】差分器515では、積分器511の出力と積分器514の出力の差分をとり、その差分をループフィルタ516に出力する。この差分についてループフィルタ516でフィルタリングした出力(差分)をシンセサイザ503にフィードバックすることによってウルトラワイドバンド信号を受信するためのタイミング同期が図られる。受信タイミングオフセットが前後にずれた場合にはタイミングオフセット信号として正負の値を出力する。参照符号509は、このようなタイミング同期を行うタイミング同期回路(DLL: Delay Lock Loop)を示す。

【0054】再び図4に戻って無線受信装置の構成例の説明を続ける。受信タイミング制御手段402は、無線送信装置が用いた配列パターンを用いて受信手段401が所定のタイミングで、受信信号の内必要な細分化スロットに対応する部分を受信するように制御する。例えば、先に送信装置の説明においてあげたスロット番号4, 3, 6, 5に相当するスロット化データを、11, 44, 58, 79のタイミングで送信手段に送信させる例によれば、受信タイミング制御手段402は11, 44, 58, 79のタイミングで受信手段401に受信させるように制御する。スロット配列制御手段405は、前記配列パターンを参照して、フレームの11, 44, 58, 79番スロットに対応する部分を復調するように制御する。端末の初期状態(電源ON直後など)では、配列パターンの同期を獲得する必要があるため、相関器406が必要となる。相関器の動作の具体的説明は後述する。

【0055】スロット配列手段403は、受信手段401から出力される受信データを受け取る。スロット配列手段403は、受信データをスロット配列制御手段405の制御により当初の順番となるように配列を行う。例えば前記の例によれば、スロット配列手段403が受け取ったスロット化データは、スロット番号4, 3, 6, 5の順になっているので、これを当初の順番であるスロット番号3, 4, 5, 6となるように配列を行う。

【0056】エラー訂正手段403は、配列されたスロット化データをまずデインターリーブ(De-Interleave)し、その後誤り訂正を行うことによって、情報データを生成し、出力する。

【0057】この構成により、無線受信装置は前記の無線送信装置から送信された情報データを復元することができる。

【0058】[無線送信装置及び無線受信装置の動作]次に、本実施の形態における無線送信装置及び無線受信装置の動作について説明する。まず、無線送信装置は、1フレーム時間に対応する情報データを、符号化及びイ

ンターリーブ手段201により符号化する。さらに符号化された情報ビットを符号化手段201によりインターリーブし、インターリーブした情報ビットを1スロット分のデータ(ビット)毎にスロット化データとしてまとめる。

【0059】その後無線送信装置は、送信タイミング制御手段203によって予め定められたスロット配列パターンにしたがって決められたタイミングで該スロット化データを送信手段204に送信させる。

【0060】無線送信装置から送信された無線信号は、伝送路で干渉波などの妨害をうけて受信信号として無線受信装置に到達する。

【0061】無線受信装置は、受信タイミング制御手段402が前記予め定められたスロット配列パターン(送信装置が用いたスロットパターンと同一)に応じて、受信信号のうち必要なスロット部分を受信するように受信手段401を制御する。

【0062】受信タイミング制御手段402によってタイミング制御されている受信手段401は、配列されたスロット化データを出力する。配列されたスロット化データはスロット配列手段403によって、前記スロット配列パターンに応じて配列されたスロット化データを配列する。

【0063】スロット配列手段403によって配列されたスロット化データは、エラー訂正手段404によってデ・インターリーブ及び誤り訂正を施され、情報データに変換される。これにより、無線受信装置は、無線送信装置から送信された情報データを得ることができる。

【0064】[本実施の形態にかかる無線ネットワークの動作例]次に、本実施の形態にかかる無線ネットワークの動作例について説明し、ランダムスロットアサイン(Random Slot Assign)方法と、それにより干渉波をどう扱うかをしめす。図6は、2つのネットワークPANX601とPANY602が近接して配置されている様子を示している。

【0065】ネットワークPANX601は、基地局X603と、該基地局X603によって制御される端末局A605、端末局B606、端末局C607および端末局F610とにより構成される。一方、ネットワークPANY602は、基地局Y602と、該基地局Y602によって制御される端末局D608および端末局E609とにより構成されている。なお、基地局及び各端末局は本実施の形態における無線送信装置、及び無線受信装置として機能する。

【0066】また、端末局C607と端末局E609は、両局が同時に無線送信をした場合に一方の無線送信信号が他方の無線送信信号に無視できない妨害を与えるような距離にあるものとする。

【0067】また、ネットワークPANX601と、ネットワークPANY602は互いに独立に運用されてい

て、互いに調整されていない (Uncoordinate) 状態で運用されているものとする。

【0068】図7は、ネットワークPANX601における、ある時点でのランダムスロットアサイン方法によるフレームの使用を説明する図である。図7(A)は、あるフレームにおけるチャネル割り当て状態を示している。このチャネル割り当ては、一般的には基地局が行う。この例では、ビーコン701、端末局Aへのユーザ割当領域702、端末局Bへのユーザ割当領域703、端末局Fへのユーザ割当領域704、コンテンツン・ピリオド705がフレームに含まれている。端末局Fへのユーザ割当領域704においては、端末局F610から端末局C607に宛てての送信が行われる。

【0069】図7(B)は、端末局Fへのユーザ割当領域704において送信される情報が複数の細分化スロットに割り付けられている状態を示す図である。ユーザ割当領域704は、細分化スロット706L、706L+1、706L+2、706L+3、…、706Mに対応する。なお、Lは、ユーザ割当領域704の開始位置に対応するスロット番号、Mはユーザ割当領域704の終了位置に対応するスロット番号を表すものとする。

【0070】端末局Fは、所定のスロット配列パターンに応じて、細分化スロットの配列を行い、該スロット配列パターンに応じたタイミングで情報データを送信する。図7(C)は、端末局Fが送信データをスロット配列パターンに応じたタイミングで送信する様子を示している。この例では、図7(B)におけるスロット706Lは、フレーム中の第3スロットのタイミングで送信され、スロット706L+1は、フレーム中の第7スロットのタイミングで送信され、スロット706L+2は、フレーム中の第11スロットのタイミングで送信され、スロット706L+3は、フレーム中の第14スロットのタイミングで送信され、…、スロット706Mは、フレーム中の第(N-7)スロットのタイミングで送信される。このようにして、送信データはスロット配列パターンに応じたタイミングで送信される。

【0071】スロット配列パターンは、スロット化データをフレーム内にランダムに配置するためのパターンであって、例えば所定の乱数によりスロット番号をシャッフル (permutate) することによって生成される。また、スロット配列パターンは1つのみでなく複数のものを用いるようにしても良い。但し、同一ネットワーク内における全ての基地局および端末局は所定の生成規則に従ってランダム化されていることを予め把握していることが望ましい。フレームの先頭を示すビーコンを含めてスロットをシャッフルしてしまうからである。

【0072】図7(D)は、端末局F (端末局C宛の通信のためのリソース) へのユーザ割当領域704のみでなく、1フレーム全体、すなわちビーコン701、端末局Aへのユーザ割当領域702、端末局Bへのユーザ割当

領域703、コンテンツン・ピリオド705が細分化スロットに分割され、さらにこれらスロット位置を組みかえて送信されている様子を示す図である。図に示す例では、データ707は、端末局Aによってスロット配列パターンに応じたタイミングで送信されたデータの一つであり、データ708は、基地局によってスロット配列パターンに応じたタイミングで送信されたデータのの一つ (ビーコンの一部) であり、データ709は、端末局Fによってスロット配列パターンに応じたタイミングで送信されたデータのの一つであり、データ710は、端末局Bによってスロット配列パターンに応じたタイミングで送信されたデータのの一つであり、データ711は、端末局のいずれかによってスロット配列パターンに応じたタイミングで送信されたデータのの一つ (コンテンツン・ピリオドで送信されるデータの一部) である。

【0073】次に、端末局C607が端末局Fから送信された信号を受け取るに際して、他のパーソナル・エリア・ネットワークに属する端末局Eからの送信信号による干渉を受ける様子を説明する。

【0074】図8(A)は、ネットワークPANY602におけるフレームの送信状況を示す図である。ネットワークPANY602においても、ネットワークPANX601と全く独立のランダムスロットアサイン方法によってデータがランダムにフレーム内に配されて送信が行われている。図中、端末局Eにより送信されるデータを符号801によって示す。

【0075】図8(B)はネットワークPANX601におけるフレームの送信状況を示す図であって、図7(D)と同じである。

【0076】端末局Eからの送信データは、端末局Cがデータを受信するタイミング802において妨害を与えている。

【0077】図8(C)は端末局Cが前記スロット配列パターンに応じたタイミングで受信信号のうち必要な部分を受信した信号を集めた様子を示している。集められた信号は端末局Eからの送信信号による干渉を受けないデータに対応する部分803と、端末局Eからの送信信号による干渉を受けるデータに対応する部分804とを有している。

【0078】この集められたデータは、デ・インターリーブされ、符号化データに戻され、符号化データはエラー訂正により復号され、受信情報ビットが得られる。

【0079】ここに示したように、ランダムスロットアサイン方法によって、フレーム内のランダムなスロット位置に配列されている端末局Eの送信信号は、端末局Cの受信に際し、確率的に低い確率で妨害を与えているのみであるので、この妨害によって生じたエラーは訂正され正しく復号されることが期待できる。

【0080】[コンテンツン・ピリオドの使い方] 次に、ランダムスロットアサイン方法におけるコンテンツン

ョン・ピリオドの扱いについて説明する。

【0081】コンテンツン・ピリオドに相当するスロットを使用する場合において、かかるスロットを使用する端末局は、所定の数（たとえば8）の連続したスロットを最小単位として利用する。連続したスロットを使用すれば、ランダムスロットアサイン方法におけるスロット配列パターンに従って、フレーム内にランダムに配置されるので、コンテンツン・ピリオドにおいて送信するスロット化データについても、図8(C)に例示するような他の局の送信信号に対してランダムな部分的干渉を与えることになり、あるいは他の局の送信信号からランダムな干渉を被るようになるので、この妨害によって生じたエラーは訂正され正しく復号されることが期待できる。

【0082】〔スロット配列の方法について〕次に、本実施の形態におけるランダムスロットアサイン方法のスロットの配列方法について説明する。スロットの配列方法は、他の局の送信信号に対してランダムな部分的干渉を与えることになり、あるいは他の局の送信信号からランダムな干渉を被るようにする配列方法であればいずれであっても良く、たとえば以下のような配列方法が考えられる。0. 図7に示したように、フレーム内の1チャンネルを1フレーム全体にランダムに配列する方法である。説明は省略する。1. 1フレーム若しくは1チャンネル内の1番からN番までのN個のスロットを完全にランダムに配列する方法がある。図9(A)は、配列前のスロットを示し、図9(B)はN個のスロットがランダムに配列される様子を示している。2. 別の配列方法として、スロットをグループ化してからランダムに配列する方法がある。この方法を図10(A)から(C)を参照しながら説明する。

【0083】まず、図10(A)に示すように、N個のスロットからなるフレームにおいて、J個（たとえばJ=4）の連続したスロットを一つのグループ1001とし、N/J個のグループを作る。

【0084】次に、図10(B)に示すように、各グループ1001から1のスロットを一つずつJ個のスロット群1002に割り振る。各スロット群1002は、J個のスロットを有することになる。

【0085】最後に、各スロット群1002においてJ個のスロットをランダムに配列する。図10(C)は各スロット群1002においてJ個のスロットをランダムに配列された後の状態を示している。

【0086】この配列方法によれば、J個の連続するスロットはそれぞれ、フレーム内のJ個のブロック（スロット群）に分散して配列されることが保証され、その結果フレームの一部に特定の領域のスロットが偏って配置されることがないようなランダムかつ分散された配置をおこなうことが可能となる。

【0087】〔配列パターン同期方法〕先に述べたよう

に、本実施の形態においては、同一パーソナル・エリア・ネットワークにいる通信機（基地局、端末局双方を含む）はすべてスロット配列パターン若しくは該パターンを生成する生成規則を知っていることが望ましい。スロット配列パターンは数多くのフレームにわたって同一のものが出現しないほうが、他のネットワークの局との衝突をランダムにする目的において望ましい。

【0088】まず、図11(A)に示すように、基地局はフレーム1101毎に送信されるビーコンの1部として、同期用パターンを送信する。ところが、端末局は初期状態（電源ON直後など）では、基地局が使用するスロット配列パターン若しくはその生成規則を把握することはできるが、該スロット配列パターンのどこを今送信しているのかは知り得ない。

【0089】そこで配列パターン同期を獲得するための既知の同期用パターン（例えば細分化スロット長に等しい長さを有する同期ワード）をあらかじめ定められておき、各通信機にこれを記憶させておく。この同期用パターンを含むスロットを複数用意し（1102）、これら信号列を含むスロット（同期用スロットという）1103が送信されるときはランダムスロットアサイン法によるスロット配列パターンに応じてフレーム内のランダムな位置に配置されるようにする（図11(B)参照）。

【0090】端末局側は、同期用スロット1103に含まれる配列パターンを獲得するための既知パターンに対応する相関器（図4、406）を用いて、同期用スロットの検出及び位置特定を行う。図11(C)は、かかる相関器の出力信号904を示す波形図であって、同期用スロット位置に対応した相関のピークが現れる。端末局はまず1つ1つの同期用スロットを検出する。次に同期用のパターンを検出し、検出された同期用スロットの位置パターンを記憶する。

【0091】この検出された同期用スロット位置のパターンと、スロット配列パターンとを比較して、現在送信されているスロット配列パターンの位置を特定する。これにより端末局は、スロット配列パターンのどこを送信しているのかを見つけ、それ以降は、記憶しているスロット配列パターン若しくはその生成規則を用いて、自立的に該スロット配列パターンを発生して、基地局が使用するスロット配列パターンとの同期をとることが出来る。

【0092】また、本方法によれば、矛盾なくスロット配列パターンの同期がとれることは、フレームの区切りにも同期したことになり、フレーム同期も同時に達成できることになる。

【0093】〔同期用パターンの別の構成例〕上述の同期用パターンは、1スロット長と同一となるような信号列を用いたが、スロット長よりも短い同期ワードの繰り返しを用いて同期用スロットを構成することも考えられる。スロット長が同期ワードの長さの整数倍になってい

ない場合は、規則的に並べた同期ワードの繰り返しを用いる。

【0094】図12に、規則的に並べた同期ワードの繰り返しを用いる同期用パターンの例を示す。

【0095】図12(A)は、あるフレームにおける同期用スロット1201が配置されている様子を示す図である。

【0096】基地局は同期用スロット長より短い同期ワード1202を繰り返し生成する。図12(B)は、同期ワードが繰り返し生成されている様子を示す図である。

【0097】基地局は、同期用スロット1201を窓として前記繰り返し生成される同期ワードにかけて取り出したもの(窓同期ワード)1203を得て、これを伝送する。図12(C)は、取り出された窓同期ワード1203が同期用スロットに対応するタイミングで送信される様子を示す。

【0098】受信側では、同期ワードに対する相関をとる。最初の相関がとれれば、が異動期ワードの周期(ワード長)で巡回するカウンタ等を用いることにより、それ以降に受信する同期ワードとの同期をとることが可能となる。

【0099】かかる構成の同期方法を用いれば、同期ワードとスロット長の関係の制約を少なくすることが出来、同期ワードの選択及びスロット長の設定に関する自由度を増すことができる。

【0100】[変形例] 上述の実施の形態においては、デ・インターリーブおよび符号化を行うとしたが、本実施の変形例では、妨害によってデータエラーが起こることを許容できる通信においては、相手に与える干渉をランダムにするためには行うが、自分の送信データは符号化しないようにしてもよい。

【0101】また、さらに別の変形例では、デ・インターリーブ、符号化をともに省略しても良い。

【0102】[その他の変形例] 上述の無線送信装置、無線受信装置の構成例においては、中央制御部として機能するCPUがEEPROMなどに格納されたプログラムに基づいてランダムスロットアサイン法によるデータの無線送受信処理を行うものとしたが、本発明はこれに限らず、該プログラムが記録されたプログラム記録媒体からこのプログラムを無線送信装置、無線受信装置に読みとらせ、ランダムアサイン法によるデータの無線送受信処理の全部又は一部を無線送信装置、無線受信装置のCPUに行わせるようにしても良い。

【0103】かかるプログラム記録媒体は、例えばフロッピー(登録商標)ディスク、CD-ROM、DVD等のパッケージメディアのみならず、プログラムが一時的若しくは永続的に格納される半導体メモリや磁気ディスクなどであってよい。また、これらプログラム記録媒体にプログラムを格納する手段としては、ローカルエリア

ネットワーク、インターネット、デジタル通信衛星等の有線または無線通信手段を利用してプログラムをダウンロードし、これをプログラム記録媒体に書き込むようにしても良く、またルータやモデム等の通信機器を介在させて格納するようにしても良い。

【0104】

【発明の効果】互いに調整されていない2つ以上の無線ネットワークが相互に干渉を受ける位置に存在しても、干渉を受けるスロットと受けないスロットが存在し、干渉を受けたスロットはでインターリーブ・符号化でエラー訂正され正しく伝送できる。

【図面の簡単な説明】

【図1】(A)は、所定の長さを有するフレームを示す図であり、(B)は、1フレームがN個のスロットに分けられる様子を示す図であり、(C)は、1スロットの構成を示す図であり、(D)は、スロットに含まれる情報ビットを示す図であり、(E)は、1ビットを示すパルス列の例を示す図である。

【図2】実施の形態にかかる送信装置の構成例を示すブロック図である。

【図3】送信装置の送信手段の構成例を示すブロック図である。

【図4】実施の形態にかかる受信装置の構成例を示すブロック図である。

【図5】受信装置の受信手段の構成例を示すブロック図である。

【図6】2つの無線ネットワークの構成を示す図である。

【図7】(A)は、本実施の形態におけるフレームのリソース割り当て状態を示す図であり、(B)は、ユーザ割当領域704のスロット化を示す図であり、(C)は、ユーザ割当領域704のスロット化データがスロット配列パターンに応じてフレームに配置された様子を示す図であり、(D)は全てのスロットがスロット配列パターンに応じてフレームに配置された様子を示す図である。

【図8】(A)は、PANYに関するフレームを示す図であり、(B)は図7(D)に対応するPANXに関するフレームを示す図であり、(C)は端末局Cが受信するスロット化データの状態を示す図である。

【図9】(A)は、配列前のスロットを示す図であり、(B)はN個のスロットがランダムに配列される様子を示す図である。

【図10】(A)は、N個のスロットからなるフレームにおいて、J個の連続したスロットを一つのグループにする様子を示した図であり、(B)は、各グループから1のスロットを一つずつJ個のスロット群に割り振りをした後の状態を示す図であり、(C)は、各スロット群においてJ個のスロットをランダムに配列した後の状態を示している図である。

【図11】(A)は、同期パターンを含むフレームを示す図であり、(B)はフレーム内に同期用スロットがスロット配列パターンに応じて配列された状態を示す図であり、(C)は同期用スロットに対応する相関器の出力波形を示す図である。

【図12】(A)は、あるフレームの位置部において同期用スロットが配置されている様子を示す図であり、同期ワードが繰り返り生成されている様子を示す図であり、(C)は、取り出された窓同期ワード1203が同期用スロットに対応するタイミングで送信される様子を示す図である。

【図13】(A)は、従来のTDMAフレームを示す図、(B)は従来のTDMAフレームの構成例を示す図である。

【図14】2つのネットワークが近接して配置されている図である。

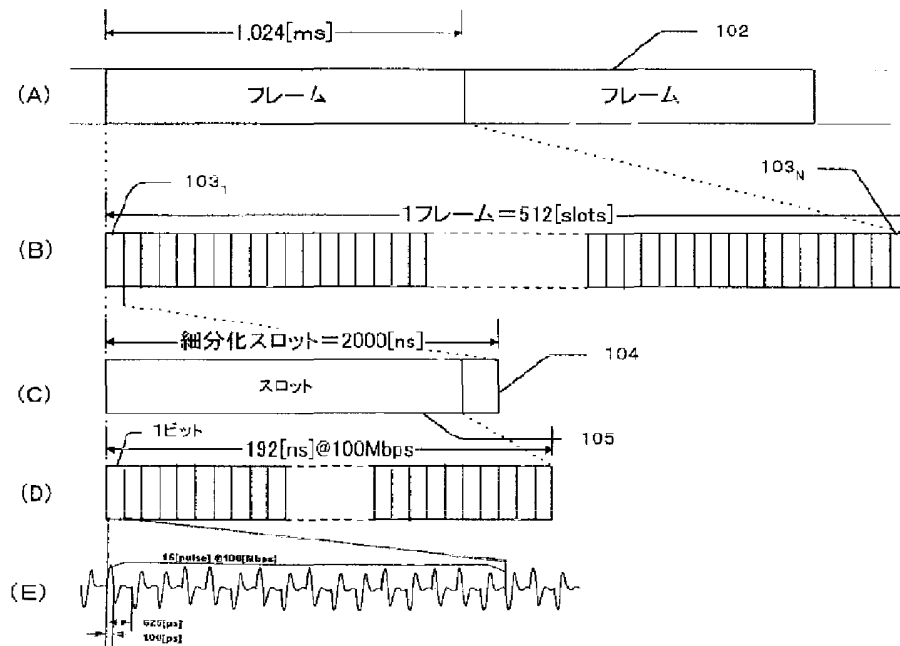
【図15】(A)は、図14のネットワークXにおける

フレーム構成を示す図であり、(B)は、図14のネットワークYにおけるフレーム構成を示す図である。

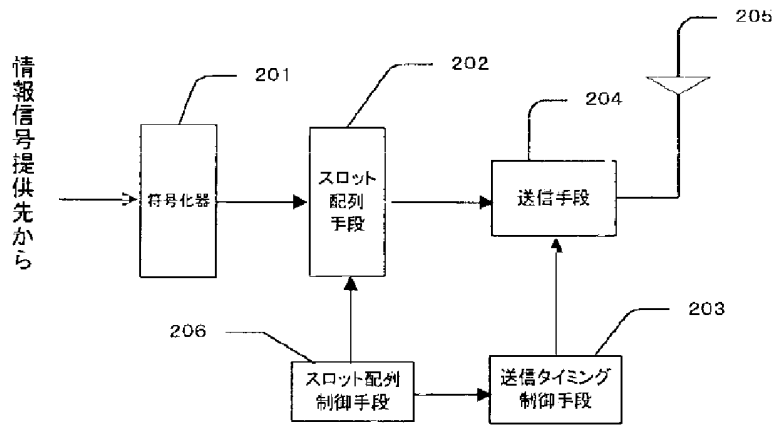
【符号の説明】

- 101、102 … フレーム
- 103 … 細分化スロット
- 104 … ガード・ピリオド
- 201 … 符号化(及びインターリーブ)手段
- 202 … スロット配列手段
- 203 … 送信タイミング制御手段
- 204 … 送信手段
- 206 … スロット配列制御手段
- 401 … 受信手段
- 402 … 受信タイミング制御手段
- 403 … スロット配列手段
- 404 … エラー訂正手段
- 405 … スロット配列制御手段

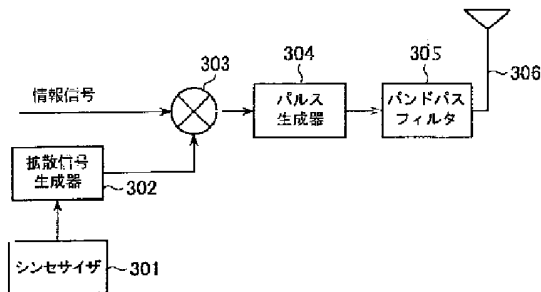
【図1】



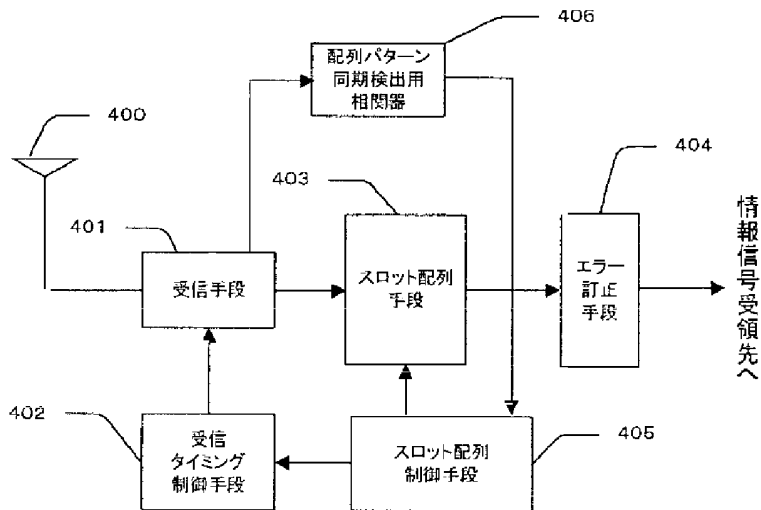
【図2】



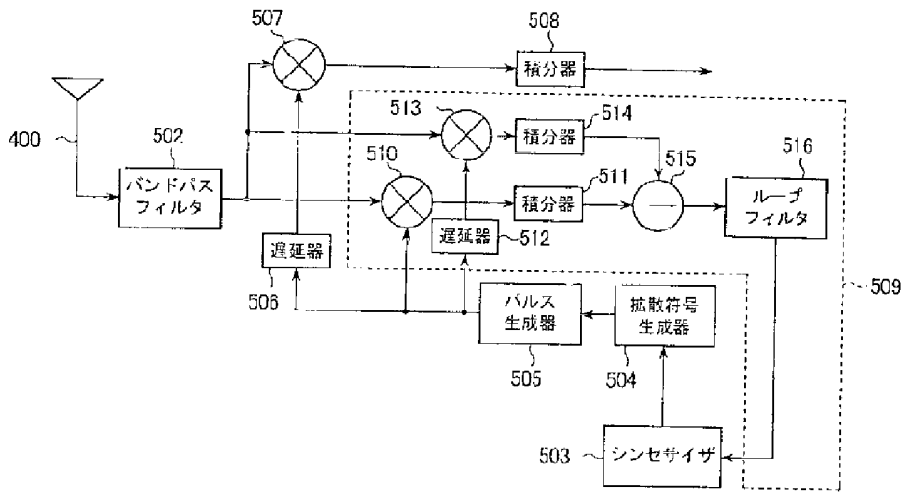
【図3】



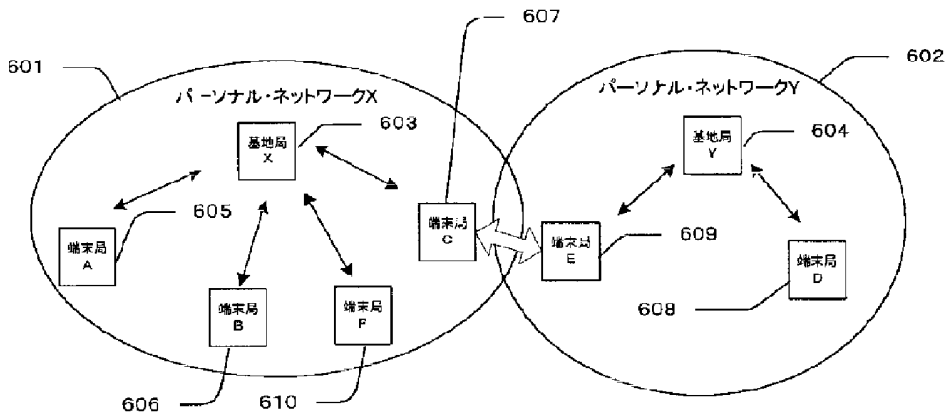
【図4】



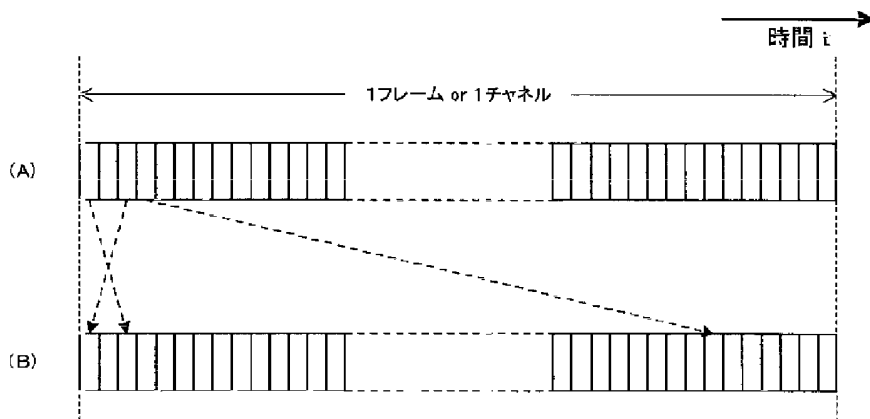
【図5】



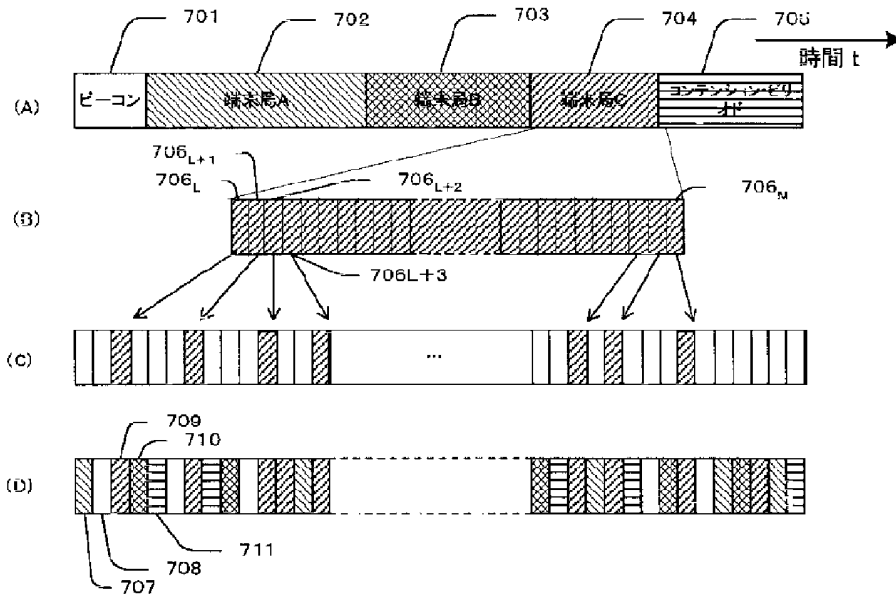
【図6】



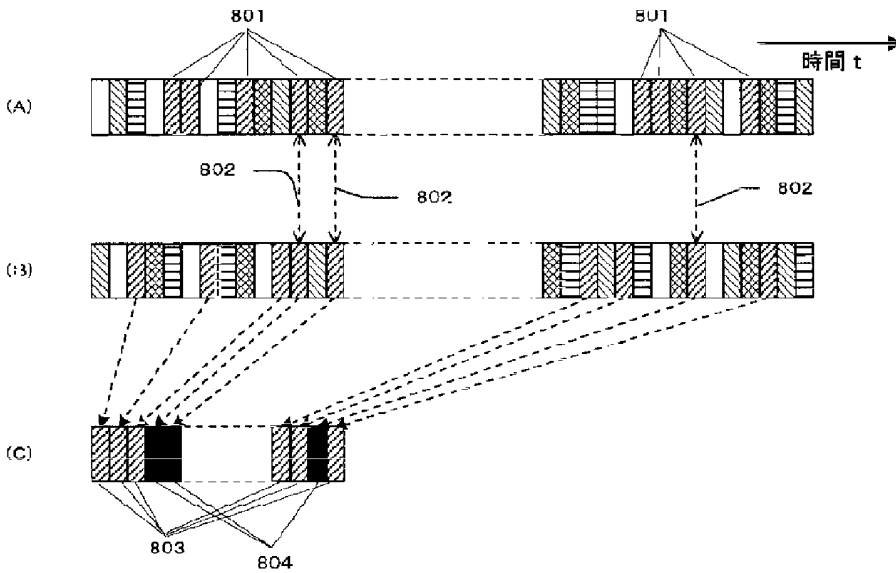
【図9】



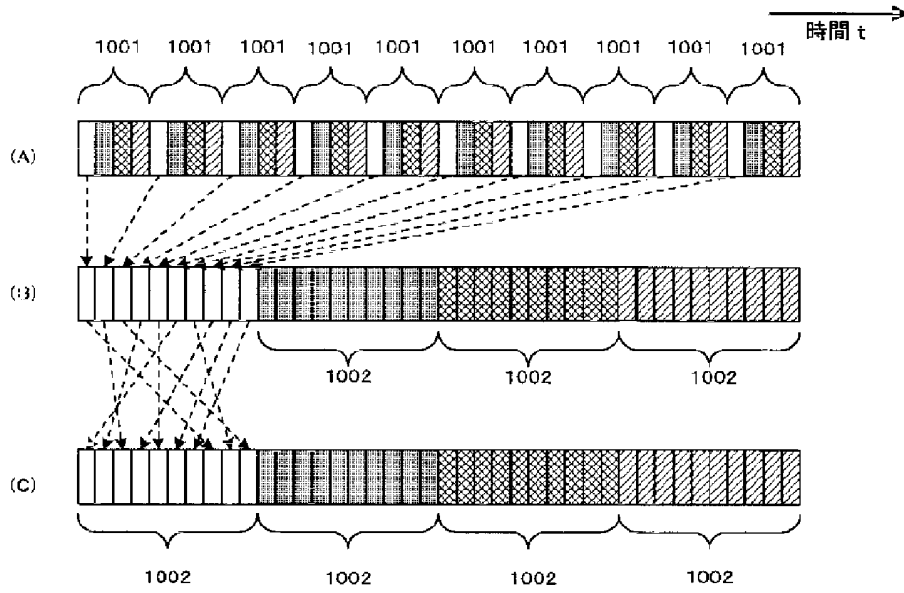
【図7】



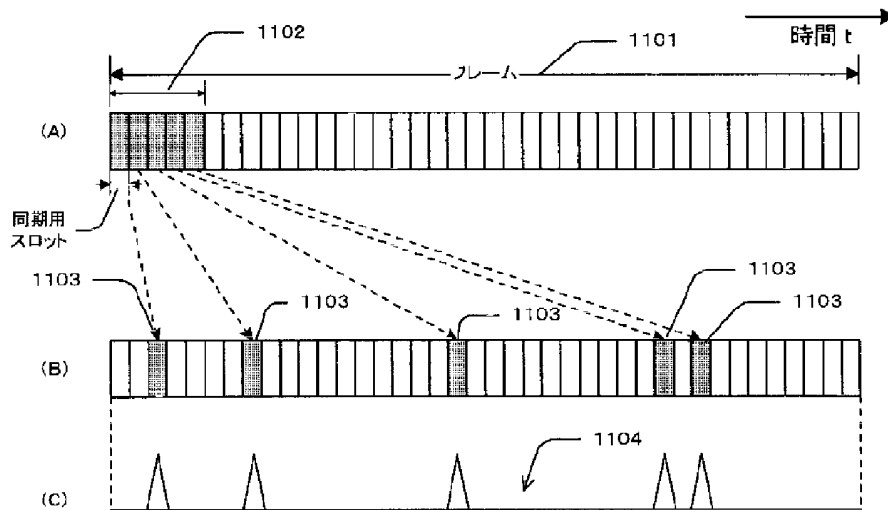
【図8】



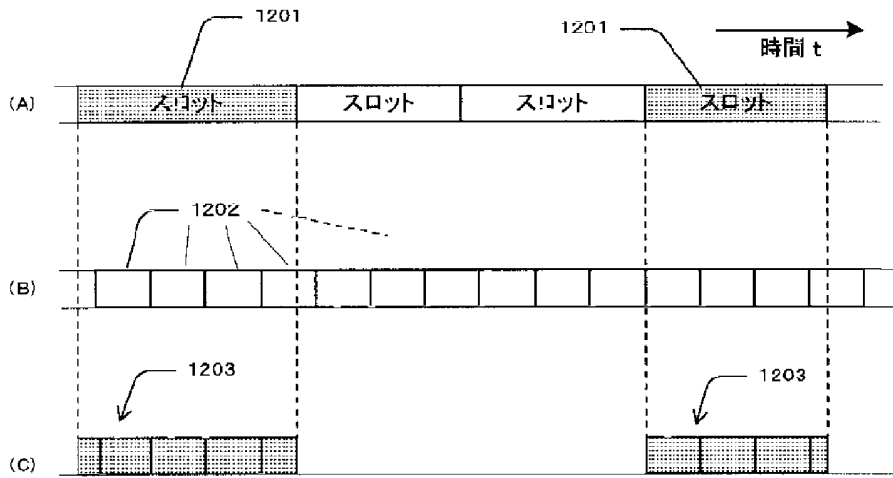
【図10】



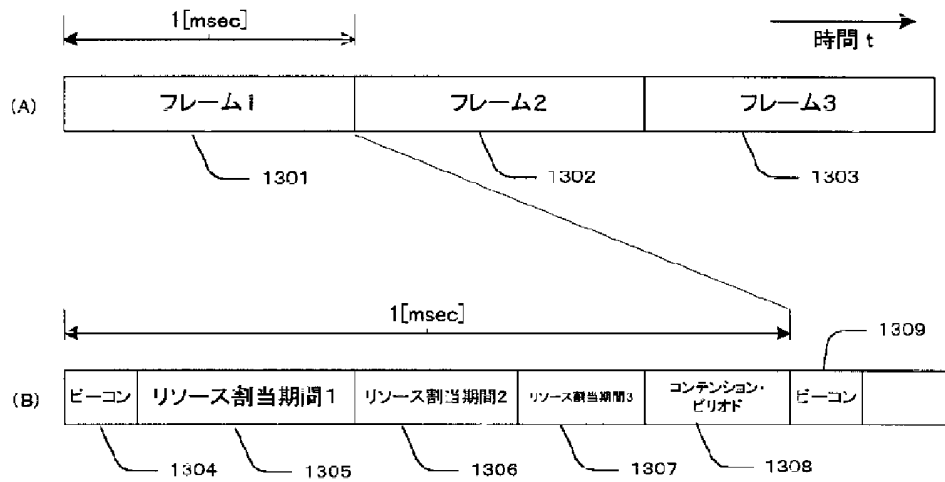
【図11】



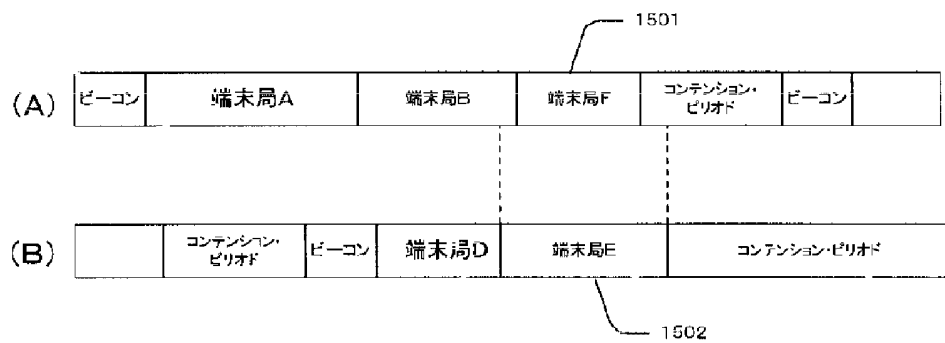
【図12】



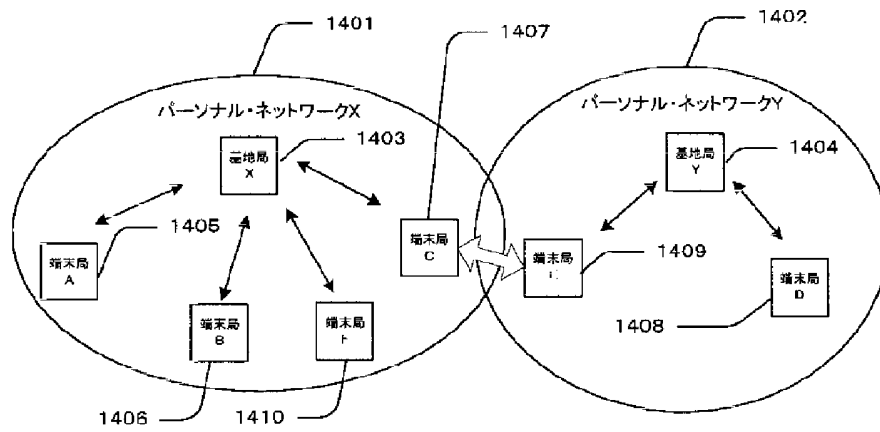
【図13】



【図15】



【図14】



Electronic Patent Application Fee Transmittal

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First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Filer:	David Gerard Majdali/Neeti Rajput
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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	1806	1	180	180
Total in USD (\$)				180

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	12303947
	Filing Date	2010-07-07
	First Named Inventor	Yeong Hyeon Kwon
	Art Unit	2478
	Examiner Name	KHAJURIA, SHRIPAL K
	Attorney Docket Number	2101-3596

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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FOREIGN PATENT DOCUMENTS								Remove
Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ² j	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1	2000102067	JP		2000-04-07	MITSUBISHI ELECTRIC CORP		<input type="checkbox"/>
	2	2001268051	JP		2001-09-28	NTT DOCOMO INC		<input type="checkbox"/>
	3	2003179576	JP		2003-06-27	SONY CORP		<input type="checkbox"/>

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	KHAJURIA, SHRIPAL K
Attorney Docket Number	2101-3596

4	2005/055527	WO		2005-06-16	QUALCOMM INC	<input type="checkbox"/>
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NON-PATENT LITERATURE DOCUMENTS Remove

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, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1		<input type="checkbox"/>

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EXAMINER SIGNATURE

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

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	KHAJURIA, SHRIPAL K
Attorney Docket Number	2101-3596

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

- See attached certification statement.
- The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.
- A certification statement is not submitted herewith.

SIGNATURE

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	/David Majdali/	Date (YYYY-MM-DD)	2012-04-18
Name/Print	David Majdali	Registration Number	53,257

This collection of information is required by 37 CFR 1.97 and 1.98. 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 1 hour 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.**

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 the Freedom of Information Act requires disclosure of these records.
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 inspections 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.

Electronic Acknowledgement Receipt

EFS ID:	12576106
Application Number:	12303947
International Application Number:	
Confirmation Number:	1730
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Customer Number:	35884
Filer:	David Gerard Majdali/Neeti Rajput
Filer Authorized By:	David Gerard Majdali
Attorney Docket Number:	2101-3596
Receipt Date:	18-APR-2012
Filing Date:	07-JUL-2010
Time Stamp:	21:20:17
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	\$ 180
RAM confirmation Number	9583
Deposit Account	502290
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

SAMSUNG 1005-0819

EVOLVED-0002464

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	2101-3596_41812_IDSform.pdf	612340 b9528ae1ec3c82a35848e04e21816f51ce2d3311	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
2	Foreign Reference	JP2000-102067.pdf	773765 209f729cdc8011ef4636f7b902cc103d300df036	no	9
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Information:					
3	Foreign Reference	JP2001-268051.pdf	1963524 d2b0ef62f7e495eba21ddb750195bd45dc94bcc9	no	24
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Information:					
4	Foreign Reference	JP2003-179576.pdf	1870793 51772502832c3b251b1d808d950b011d69acea6	no	20
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6	Fee Worksheet (SB06)	fee-info.pdf	30788 f31749793a85a3e27a2195ab8742552573da4a4	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			12177809		

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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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	12303947
	Filing Date	2010-07-07
	First Named Inventor	Yeong Hyeon Kwon
	Art Unit	2478
	Examiner Name	KHAJURIA, SHRIPAL K
	Attorney Docket Number	2101-3596

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ² j	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T ⁵
/S.K./	1	2000102067	JP		2000-04-07	mitsubishi electric corp		<input type="checkbox"/>
/S.K./	2	2001268051	JP		2001-09-28	NTT DOCOMO INC		<input type="checkbox"/>
/S.K./	3	2003179576	JP		2003-06-27	SONY CORP		<input type="checkbox"/>

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	KHAJURIA, SHRIPAL K
Attorney Docket Number	2101-3596

/S.K./	4	2005/055527	WO		2005-06-16	QUALCOMM INC	<input type="checkbox"/>
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If you wish to add additional Foreign Patent Document citation information please click the Add button **Add**

NON-PATENT LITERATURE DOCUMENTS

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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, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1		<input type="checkbox"/>

If you wish to add additional non-patent literature document citation information please click the Add button **Add**

EXAMINER SIGNATURE

Examiner Signature	/Shripal Khajuria/	Date Considered	04/24/2012
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

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STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	12303947
Filing Date	2010-07-07
First Named Inventor	Yeong Hyeon Kwon
Art Unit	2478
Examiner Name	KHAJURIA, SHRIPAL K
Attorney Docket Number	2101-3596

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- See attached certification statement.
- The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.
- A certification statement is not submitted herewith.

SIGNATURE

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	/David Majdali/	Date (YYYY-MM-DD)	2012-04-18
Name/Print	David Majdali	Registration Number	53,257

This collection of information is required by 37 CFR 1.97 and 1.98. 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 1 hour 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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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)).
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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.

Customer No. 035884

Docket No. 2101-3596

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Yeong Hyeon KWON et al.

Serial No.: 12/303,947

Filed: July 7, 2010

For: METHOD OF TRANSMITTING DATA IN A
MOBILE COMMUNICATION SYSTEM

Art Unit: 2478

Examiner: Khajuria, Shripal K.

Conf. No. 1730

**AMENDMENT AFTER NOTICE OF
ALLOWANCE (NOA) PURSUANT TO
37 CFR 1.312**

Mail Stop Issue Fee
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Notice of Allowance dated March 6, 2012, for which the Issue Fee is due June 6, 2012, this paper is submitted prior to payment of the Issue Fee. Applicant respectfully requests that the Examiner amend the above-identified application as follows prior to issuance:

IN THE SPECIFICATION:

Please amend the first paragraph at line 1 on page 1 as follows:

This application is the National Stage filing under 35 U.S.C. § 371 of International Application No. PCT/KR07/02784, filed on ~~January~~ June 8, 2007, which claims the benefit of earlier filing date and right of priority to Korean Application Nos. 10-2006-0052167, filed on June 9, 2006, and 10-2006-0057488, filed on June 26, 2006.

REMARKS

Claims 31-46, which are all the claims in the application, have been allowed. Applicant respectfully submits that the amendments to the specification are intended to correct formal matters and do not change the scope of the claims.

The foregoing amendment to the specification corrects a typographical error in the filing date of PCT Application No. PCT/KR07/02784. It is respectfully noted that the filing date of June 8, 2007 was correctly listed on PCT Publication No. WO 2007/042492, and on the Declaration/Power of Attorney filed on July 7, 2010.

The specification has been amended to reflect the issued status of the parent application. No new matter has been added to the specification. In view of the allowance of claims 31-46, which have not been amended with this paper, it is respectfully submitted that claims 31-46 are still in condition for allowance. The Examiner is requested to issue a Response to Rule 312 Communication (PTO-271) as soon as possible.

If for any reason the Examiner finds the proposed amendments not in condition for entry or if further changes are deemed necessary, the Examiner is requested to call the undersigned attorney at the Los Angeles, California, telephone number (213) 623-2221.

Respectfully Submitted,
LEE, HONG, DEGERMAN, KANG & WAIMEY

Date: May 3, 2012

By: /Ali Atefi/
Ali Atefi
Registration No. 63,960
Attorney for Applicant(s)

Customer No. 035884

Electronic Acknowledgement Receipt

EFS ID:	12700958
Application Number:	12303947
International Application Number:	
Confirmation Number:	1730
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Customer Number:	35884
Filer:	Ali. Atefi/Anna Tounian
Filer Authorized By:	Ali. Atefi
Attorney Docket Number:	2101-3596
Receipt Date:	03-MAY-2012
Filing Date:	07-JUL-2010
Time Stamp:	19:13:05
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		2101-3596-312Amendment.pdf	82611 <small>32c07c3c8627f173b08d1939ff6f909c084e280a</small>	yes	3

Multipart Description/PDF files in .zip description			
Document Description		Start	End
Amendment after Notice of Allowance (Rule 312)		1	1
Specification		2	2
Applicant Arguments/Remarks Made in an Amendment		3	3

Warnings:

Information:

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New Applications Under 35 U.S.C. 111

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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

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 P.O. Box 1450
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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.

33884 7990 05906/0612
LEE, HONG, DEGERMAN, KANG & WAIMEY
 660 S. FIGUEROA STREET
 Suite 2300
 LOS ANGELES, CA 90017

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.
12/303,947	07/07/2010	Yeong Hyeon Kwon	2101-3596	1730

TITLE OF INVENTION: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM

APPL. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEES DUE	DATE DUE
nonprovisional	NO	\$1740	\$300	\$0	\$2040	06/06/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
KHAURIA, SHRIPAL K	2478	370-328000

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 OK, 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. **LEE, HONG, DEGERMAN, KANG & WAIMEY**
 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: **LG ELECTRONICS INC.**
 (B) RESIDENCE: (CITY AND STATE OR COUNTRY) **SEOUL, REPUBLIC OF KOREA**

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) is/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-2030 is attached.
 The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 50-2290 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)
 a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant, a registered attorney or agent, or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Ali Atefi/ Date June 5, 2012
 Typed or printed name Ali Atefi Registration No. 63,960

This collection of information 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.

Electronic Patent Application Fee Transmittal

Application Number:	12303947
Filing Date:	07-Jul-2010
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Filer:	Ali. Atefi/Anna Tounian
Attorney Docket Number:	2101-3596

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

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	1501	1	1740	1740
Publ. Fee- early, voluntary, or normal	1504	1	300	300

SAMSUNG 1005-0832

EVOLVED-0002477

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				2040

Electronic Acknowledgement Receipt

EFS ID:	12943035
Application Number:	12303947
International Application Number:	
Confirmation Number:	1730
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Customer Number:	35884
Filer:	Ali. Atefi/Anna Tounian
Filer Authorized By:	Ali. Atefi
Attorney Docket Number:	2101-3596
Receipt Date:	05-JUN-2012
Filing Date:	07-JUL-2010
Time Stamp:	21:43:17
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	\$2040
RAM confirmation Number	7133
Deposit Account	502290
Authorized User	LEE, HONG, DEGERMAN, KANG & WAIMEY

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 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	Transmittal Letter	2101-3596-Transmittal-IssueFee.pdf	71729 9d19c73a415a8c2b0c626b2d5fae41f2cbd317d7	no	1
Warnings:					
Information:					
2	Issue Fee Payment (PTO-85B)	2101-3596-IssueFeeForm.pdf	340824 2c05cdaff912f14d9e01bf499ce687525dc6a2ac	no	1
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	32110 d9b4c521d5b0c937c5d9da11ea1f4ac40511ba14	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			444663		

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.

Customer No. 035884

Docket No. 2101-3596

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Yeong Hyeon KWON et al.

Serial No.: 12/303,947

Filed: July 7, 2010

For: METHOD OF TRANSMITTING DATA IN A
MOBILE COMMUNICATION SYSTEM

Art Unit: 2478

Examiner: Khajuria, Shripal K.

Conf. No. 1730

TRANSMITTAL OF ISSUE FEE

Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Notice of Allowance dated March 6, 2012, enclosed are the following:

- Form Part B - Issue Fee Transmittal.
- Inventor(s) or Assignee(s) is entitled to **LARGE** entity.
- The Commissioner is hereby authorized to charge the Issue Fee in the amount of \$2,040 to the credit card and any deficiency in payment or credit any overpayment to **Deposit Account No. 502290**.

Respectfully submitted,

Lee, Hong, Degerman, Kang & Waimey

Date: June 5, 2012

By: /Ali Atefi/
Ali Atefi
Registration No. 63,960
Attorney for Applicant(s)

SAMSUNG 1005-0836

EVOLVED-0002481



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.
12/303,947	07/10/2012	8218481	2101-3596	1730

35884 7590 06/20/2012
LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

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 135 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):

Yeong Hyeon Kwon, Gyeonggi-do, KOREA, REPUBLIC OF;
Seung Hee Han, Gyeonggi-do, KOREA, REPUBLIC OF;
Hyun Hwa Park, Gyeonggi-do, KOREA, REPUBLIC OF;
Dong Cheol Kim, Gyeonggi-do, KOREA, REPUBLIC OF;
Hyun Woo Lee, Gyeonggi-do, KOREA, REPUBLIC OF;
Min Seok Noh, Gyeonggi-do, KOREA, REPUBLIC OF;

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.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

Practitioners associated with Customer Number: 62574

OR

Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

The address associated with Customer Number: 62574

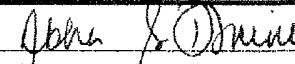
OR

<input type="checkbox"/>	Firm or Individual Name			
	Address			
	City	State	Zip	
	Country			
	Telephone	Email		

Assignee Name and Address: TQ LAMBDA, LLC
 805 Las Cimas Parkway, Suite 240
 Austin, TX 78746

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record
 The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	2/27/14
Name	Abha S. Divine	Telephone	(512) 609-1820
Title	Managing Director		

This collection of information is required by 37 CFR 1.31, 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.

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

"FEE ADDRESS" INDICATION FORM

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

Fax to:
571-273-6500

- OR -

INSTRUCTIONS: The issue fee must have been paid for application(s) listed on this form. In addition, only an address represented by a Customer Number can be established as the fee address for maintenance fee purposes (hereafter, fee address). A fee address should be established when correspondence related to maintenance fees should be mailed to a different address than the correspondence address for the application. **When to check the first box below:** If you have a Customer Number to represent the fee address. **When to check the second box below:** If you have no Customer Number representing the desired fee address, in which case a completed Request for Customer Number (PTO/SB/125) must be attached to this form. For more information on Customer Numbers, see the Manual of Patent Examining Procedure (MPEP) § 403.

For the following listed application(s), please recognize as the "Fee Address" under the provisions of 37 CFR 1.363 the address associated with:

Customer Number: **62574**

OR

The attached Request for Customer Number (PTO/SB/125) form.

PATENT NUMBER (if known)	APPLICATION NUMBER
8,218,481	12/303,947

Completed by (check one):

Applicant/Inventor

Attorney or Agent of record 45285 Jason H. Vick
 (Reg. No.) Typed or printed name

Assignee of record of the entire interest. See 37 CFR 3.71. 303-863-9700
 Statement under 37 CFR 3.73(b) is enclosed. Requester's telephone number
 (Form PTO/SB/96)

Assignee recorded at Reel _____ Frame _____ March 11, 2014
 Date

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

* Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.363. 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 5 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 COMPLETE D FORMS TO THIS ADDRESS. SEND TO: Mail Stop M Correspondence, 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.

Electronic Acknowledgement Receipt

EFS ID:	18437805
Application Number:	12303947
International Application Number:	
Confirmation Number:	1730
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Customer Number:	35884
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	2101-3596
Receipt Date:	11-MAR-2014
Filing Date:	07-JUL-2010
Time Stamp:	17:43:35
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Statement_Under_373c_w_PO A.pdf	522421 <small>fb15c26549ae785ebd7ce35ccb851a2f22cfcae9</small>	yes	3

Multipart Description/PDF files in .zip description			
Document Description		Start	End
Assignee showing of ownership per 37 CFR 3.73.		1	2
Power of Attorney		3	3

Warnings:

Information:

2	Change of Address	Fee_Address.pdf	205392	no	1
			aeb3dec5f5992513cf06fc1359b4e8e9658b503f		

Warnings:

Information:

Total Files Size (in bytes):		727813
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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.

STATEMENT UNDER 37 CFR 3.73(c)Applicant/Patent Owner: TQ LAMBDA LLCApplication No./Patent No.: 8,218,481 Filed/Issue Date: July 10, 2012Titled: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEMTQ LAMBDA LLC, a Corporation

(Name of Assignee)

(Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. The assignee of the entire right, title, and interest.
2. An assignee of less than the entire right, title, and interest (check applicable box):
- The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
- There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

- A. An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.
- B. A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: YEONG HYEON KWON et al. To: LG ELECTRONICS INC.The document was recorded in the United States Patent and Trademark Office at Reel 024647, Frame 0517, or for which a copy thereof is attached.2. From: LG ELECTRONICS INC. To: TQ LAMBDA LLCThe document was recorded in the United States Patent and Trademark Office at Reel 032343, Frame 0761, or for which a copy thereof is attached.

[Page 1 of 2]

This collection of information is required by 37 CFR 3.73(b). 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: 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.

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.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

Additional documents in the chain of title are listed on a supplemental sheet(s).

As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Signature

Jason H. Vick

Printed or Typed Name

March 11, 2014

Date

45,285

Title or Registration Number



UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/303,947	07/07/2010	Yeong Hyeon Kwon	

CONFIRMATION NO. 1730

POA ACCEPTANCE LETTER



OC000000067468470

62574
Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

Date Mailed: 04/01/2014

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/11/2014.

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.

/jtfitzhugh sr/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/303,947	07/07/2010	Yeong Hyeon Kwon	2101-3596

CONFIRMATION NO. 1730

POWER OF ATTORNEY NOTICE



OC000000067468359

35884
LEE, HONG, DEGERMAN, KANG & WAIMEY
660 S. FIGUEROA STREET
Suite 2300
LOS ANGELES, CA 90017

Date Mailed: 04/01/2014

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/11/2014.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/jtfitzhugh sr/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:



Practitioners associated with Customer Number:

62574

OR

Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:



The address associated with Customer Number:

62574

OR

Firm or Individual Name			
Address			
City	State	Zip	
Country			
Telephone	Email		

Assignee Name and Address: EVOLVED WIRELESS LLC
805 Las Cimas Parkway, Suite 240
Austin, TX 78746

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of the practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	<i>Abha S. Divine</i>	Date	October 22, 2014
Name	Abha Divine	Telephone	
Title	Managing Director		

This collection of information is required by 37 CFR 1.31, 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.

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

SAMSUNG 1005-0846

EVOLVED-0002491

Electronic Acknowledgement Receipt

EFS ID:	20565718
Application Number:	12303947
International Application Number:	
Confirmation Number:	1730
Title of Invention:	METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Yeong Hyeon Kwon
Customer Number:	62574
Filer:	Jason Vick/Joanne Vos
Filer Authorized By:	Jason Vick
Attorney Docket Number:	7836-4-PUS
Receipt Date:	30-OCT-2014
Filing Date:	07-JUL-2010
Time Stamp:	16:39:49
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		Statement_Under_373c_w_PO A_EWL.pdf	2526383 <small>87718370323572db1f4146ac00d6bd038ac64be</small>	yes	3

Multipart Description/PDF files in .zip description			
Document Description	Start	End	
Assignee showing of ownership per 37 CFR 3.73.	1	2	
Power of Attorney	3	3	

Warnings:

Information:

Total Files Size (in bytes):	2526383
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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.

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.

STATEMENT UNDER 37 CFR 3.73(c)Applicant/Patent Owner: EVOLVED WIRELESS LLCApplication No./Patent No.: 8,218,481 Filed/Issue Date: July 10, 2012Titled: METHOD OF TRANSMITTING DATA IN A MOBILE COMMUNICATION SYSTEMEVOLVED WIRELESS LLC, a Corporation

(Name of Assignee)

(Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose one of options 1, 2, 3 or 4 below):

1. The assignee of the entire right, title, and interest.
2. An assignee of less than the entire right, title, and interest (check applicable box):
- The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
- There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose one of options A or B below):

- A. An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.
- B. A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: YEONG HYEON KWON et al. To: LG ELECTRONICS INC.The document was recorded in the United States Patent and Trademark Office at
Reel 024647, Frame 0517, or for which a copy thereof is attached.2. From: LG ELECTRONICS INC. To: TQ LAMBDA LLCThe document was recorded in the United States Patent and Trademark Office at
Reel 032343, Frame 0761, or for which a copy thereof is attached.

[Page 1 of 2]

This collection of information is required by 37 CFR 3.73(b). 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: 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.

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EVOLVED-0002494

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.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: TQ LAMBDA LLC To: EVOLVED WIRELESS LLC

The document was recorded in the United States Patent and Trademark Office at
Reel 034039, Frame 0403, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

Additional documents in the chain of title are listed on a supplemental sheet(s).

As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Jason H. Vick/

October 30, 2014

Signature

Date

Jason H. Vick

45,285

Printed or Typed Name

Title or Registration Number



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/303,947	07/07/2010	Yeong Hyeon Kwon	7836-4-PUS

CONFIRMATION NO. 1730

POA ACCEPTANCE LETTER



OC000000071715188

62574
Jason H. Vick
Sheridan Ross, PC
Suite # 1200
1560 Broadway
Denver, CO 80202

Date Mailed: 11/07/2014

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/30/2014.

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.

/ttkim/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101