

PILOT SYMBOL TRANSMISSION IN WIRELESS COMMUNICATION SYSTEMS

BACKGROUND

Claim of Priority under 35 U.S.C. §119

[0001] The present Application for Patent claims priority to Provisional Application No. 60/731,111 entitled "PILOT SYMBOL TRANSMISSION IN WIRELESS COMMUNICATION SYSTEMS" filed October 27, 2005, and assigned to the assignee hereof and hereby expressly incorporated by reference herein.

I. Field

[0002] The present document relates generally to wireless communication and, amongst other things, to pilot transmission in wireless communication.

II. Background

[0003] A wireless communication system may utilize multiple transmit antennas at a base station or user station to transmit symbols or other information. The use of multiple transmit antennas improves the receiver ability to decode symbols since multiple versions of a same symbol are available to use in decoding the transmissions.

[0004] An orthogonal frequency division multiple access (OFDMA) system utilizes orthogonal frequency division multiplexing (OFDM). OFDM is a multi-carrier modulation technique that partitions the overall system bandwidth into multiple (N) orthogonal frequency subcarriers. These subcarriers may also be called tones, bins, and frequency channels. Each subcarrier is associated with a respective sub carrier that may be modulated with data. Up to N modulation symbols may be sent on the N total subcarriers in each OFDM symbol period. These modulation symbols are converted to the time-domain with an N-point inverse fast Fourier transform (IFFT) to generate a transformed symbol that contains N time-domain chips or samples.

[0005] In a frequency hopping communication system, data is transmitted on different frequency subcarriers in different time intervals, which may be referred to as "hop periods". These frequency subcarriers may be provided by orthogonal frequency

division multiplexing, other multi-carrier modulation techniques, or some other constructs. With frequency hopping, the data transmission hops from subcarrier to subcarrier in a pseudo-random manner. This hopping provides frequency diversity and allows the data transmission to better withstand deleterious path effects such as narrow-band interference, jamming, fading, and so on.

[0006] An OFDMA system can support multiple mobile stations simultaneously. For a frequency hopping OFDMA system, a data transmission for a given mobile station may be sent on a "traffic" channel that is associated with a specific frequency hopping (FH) sequence. This FH sequence indicates the specific subcarrier to use for the data transmission in each hop period. Multiple data transmissions for multiple mobile stations may be sent simultaneously on multiple traffic channels that are associated with different FH sequences. These FH sequences may be defined to be orthogonal to one another so that only one traffic channel, and thus only one data transmission, uses each subcarrier in each hop period. By using orthogonal FH sequences, the multiple data transmissions generally do not interfere with one another while enjoying the benefits of frequency diversity.

[0007] An accurate estimate of a wireless channel between a transmitter and a receiver is normally needed in order to recover data sent via the wireless channel. Channel estimation is typically performed by sending a pilot from the transmitter and measuring the pilot at the receiver. The pilot signal is made up of pilot symbols that are known *a priori* by both the transmitter and receiver. The receiver can thus estimate the channel response based on the received symbols and the known symbols.

[0008] A code division multiple access (CDMA) system has a universal frequency reuse that makes it possible for mobile users to receive and send the same signal simultaneously from and to multiple base stations or sectors of a base station. Soft and softer handoff in CDMA systems are techniques whereby mobiles near cell, and sector in the case of softer handoff, boundaries communicate the same transmitted signals to more than one base station or sector of a base station. Soft and softer handoff provides enhanced communication quality and a smoother transition compared to the conventional hard handoff. Soft and softer handoff is intrinsic to a CDMA system, as transmitted signals of different users occupy the same time and frequency allocation. Different users can be separated based on the respective spreading signatures.

[0009] Supporting soft and softer handoff in orthogonal multiple-access systems such as TDMA, FDMA and OFDMA is far more difficult and often requires special planning. For instance, in order to provide diversity a cell-specific scrambling code is used in the forward link to randomize the interference from the surrounding cells. Often, the scrambling code is different among sectors in the same cell (i.e., Node B). When the sector-specific scrambling code is applied to OFDM-based radio access in the downlink, each modulation symbol of the pilot channel suffers from inter-sector interference. The influence of inter-sector interference on the pilot channel is significant particularly for a user in handoff. However, the channel estimation using the pilot channel in the inter-sector diversity is not improved compared to the case with a one-link connection due to the inter-sector interference. Therefore, improvement in the channel estimation especially in inter-sector handover is essential.

[0010] Therefore, there is a need to find efficient approaches to provide improved channel estimation for different sectors in OFDMA systems.

SUMMARY

[0011] In certain aspects, a wireless communication apparatus comprises a memory and a circuit coupled with the processor. The memory is configured to store at least one first sequence of a group of first sequences, having a low cross-correlation with each other, of a first length and at least two second sequences of a group of second sequences, having a low cross-correlation with each other, of a second length that is different than the first length. The circuit is configured to multiply pilot symbols to be transmitted from a plurality of antenna groups utilizing the at least one first sequence and the at least two second sequences.

[0012] In another aspect, a method of transmitting pilot symbols comprises multiplying first pilot symbols for a first antenna group utilizing a first sequence of a group of first sequences, having a low cross-correlation with each other, and at least two second sequences of a group of second sequences, having a low cross-correlation with each other, and multiplying second pilot symbols for a second antenna group utilizing a third sequence of the group of first sequences and at least two fourth sequences of the group of second sequences. The first and second pilot symbols may be transmitted.

[00013] In further aspects, a processor readable medium may include instructions executable by one or more processors. The instructions may perform one or more aspects of the above method.

[00014] In an additional aspect, an apparatus for transmitting pilot symbols comprises means for multiplying first pilot symbols for a first antenna group utilizing a first sequence of a group of first sequences, having a low cross-correlation with each other, and at least two second sequences of a group of second sequences, having a low cross-correlation with each other, and means for multiplying second pilot symbols for a second antenna group utilizing a third sequence of the group of first sequences and at least two fourth sequences of the group of second sequences. The apparatus may also include one or more transmitters configured to transmit the first and second pilot symbols.

[00015] Various aspects and embodiments are described in further detail below. The applications further provide methods, processors, transmitter units, receiver units, base stations, terminals, systems, and other apparatuses and elements that implement various aspects, embodiments, and features, as described in further detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[00016] The features, nature, and advantages of the present embodiments may become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

[00017] Fig. 1 illustrates a multiple access wireless communication system according to one embodiment;

[00018] Fig. 2 illustrates a spectrum allocation scheme for a multiple access wireless communication system according to one embodiment;

[00019] Fig. 3 illustrates aspects of a multiple access wireless communication system;

[00020] Fig. 4 illustrates a block diagram of aspects of a transmitter system and a receiver system in a multi-input multi-output multiple access wireless communication system;

[00021] Fig. 5 illustrates a flow chart of aspects of a method of pilot transmission; and

[00022] Fig. 6 illustrates a block diagram of aspects of portions of a multi-sector base station.

DETAILED DESCRIPTION

[00023] Referring to Fig. 1, a multiple access wireless communication system according to one embodiment is illustrated. A base station 100 includes multiple antenna groups 102, 104, and 106 each including one or more antennas. In Fig. 1, only one antenna is shown for each antenna group 102, 104, and 106, however, one or multiple antennas may be utilized for each antenna group that corresponds to a sector of base station 100. Mobile station 108 is in communication with antenna 104, where antenna 104 transmits information to mobile station 108 over forward link 114 and receives information from mobile station 108 over reverse link 112. Mobile station 110 is in communication with antenna 106, where antenna 106 transmits information to mobile station 110 over forward link 118 and receives information from mobile station 110 over reverse link 116.

[00024] Each group of antennas 102, 104, and 106 and/or the area in which they are designed to communicate is often referred to as a sector of the base station. In the embodiment, antenna groups 102, 104, and 106 each are designed to communicate to mobile stations in a sector, sectors 120, 122, and 124, respectively, of the areas covered by base station 100.

[00025] In order to allow for efficient processing of data symbols, base station 100 may transmit pilot symbols from sectors 102, 104, and 106 that may be identified as being different from each other. In certain aspects, this may be performed even if the pilots are transmitted on the same subcarriers and at approximately the same time from two sectors at one time. For example, this may be performed by multiplying the pilot symbols of each sector by a common scrambling code for the cell and a first code with low cross-correlation, e.g. an orthogonal code, which is specific for the particular sector. In this way, interference for pilot symbols transmitted from a given sector is decreased with respect to any other sector. In addition to the first code for the sector, a second code with low cross-correlation, e.g. an orthogonal code, quasi-orthogonal, or a PN code, may be used for each portion of the code that is repeated in a given OFDM

symbol. Also, the second code with low cross-correlation are selected so that the pilot symbols transmitted from a given sector code with low cross-correlation with respect to the pilot symbols transmitted from another sector of a same or different cell.

[00026] A base station may be a fixed station used for communicating with the terminals and may also be referred to as, and include some or all the functionality of, an access point, a Node B, or some other terminology. A mobile station may also be referred to as, and include some or all the functionality of, a mobile station, a user equipment (UE), a wireless communication device, terminal, access terminal or some other terminology.

[00027] As used herein, in communication with antenna group or antenna generally refers to the antennas group or antenna that is responsible for transmission to a mobile station. In the case of transmission from a mobile station, multiple antenna groups may be utilized to receive transmissions including utilizing soft or other types of combining.

[00028] It should be noted that while Fig. 1, depicts physical sectors, i.e. having different antenna groups for different sectors, other approaches may be utilized. For example, utilizing multiple fixed "beams" that each cover different areas of the cell in frequency space may be utilized in lieu of, or in combination with physical sectors. Such an approach is depicted and disclosed in copending US Patent Application Serial No. [Not Yet Assigned], Attorney Docket No. 050917, entitled "Adaptive Sectorization In Cellular System," and filed on even date herewith, and which is incorporate herein by reference in its entirety. In such a case, different "beams" may be assigned different scrambling sequences and code with low cross-correlation s as described herein.

[00029] As discussed above, a first code with low cross-correlation is used to multiply the pilot symbols at each sector that is orthogonal or quasi-orthogonal to another first code with low cross-correlation used to multiply the pilot symbols of each other sector of the cell. In addition, a second code with low cross-correlation is utilized to multiply the pilot symbols after multiplication by the first code in each sector. This second code with low cross-correlation, which may be any number of orthogonal or quasi-orthogonal codes, is used to multiply over the length of the first code, with a different second code with low cross-correlation used in a single sector. This is illustrated in Table 1 below:

Table 1

Sector 1			Sector 2			Sector 3		
Pilot Sub- carrier	First Code	Second Code	Pilot Sub- carrier	First Code	Second Code	Pilot Sub- carrier	First Code	Second Code
f_0	$W_1(0)$	$P_1(0)$	f_0	$W_2(0)$	$P_3(0)$	f_0	$W_3(0)$	$P_5(0)$
f_2	$W_1(2)$	$P_1(2)$	f_2	$W_2(2)$	$P_3(2)$	f_2	$W_3(2)$	$P_5(2)$
f_4	$W_1(4)$	$P_1(4)$	f_4	$W_2(4)$	$P_3(4)$	f_4	$W_3(4)$	$P_5(4)$
f_6	$W_1(6)$	$P_1(6)$	f_6	$W_2(6)$	$P_3(6)$	f_6	$W_3(6)$	$P_5(6)$
f_8	$W_1(8)$	$P_2(8)$	f_8	$W_2(8)$	$P_4(8)$	f_8	$W_3(8)$	$P_6(8)$
f_{10}	$W_1(10)$	$P_2(10)$	f_{10}	$W_2(10)$	$P_4(10)$	f_{10}	$W_3(10)$	$P_6(10)$
f_{12}	$W_1(12)$	$P_2(12)$	f_{12}	$W_2(12)$	$P_4(12)$	f_{12}	$W_3(12)$	$P_6(12)$
f_{14}	$W_1(14)$	$P_2(14)$	f_{14}	$W_2(14)$	$P_4(14)$	f_{14}	$W_3(14)$	$P_6(14)$

[00030] In the examples of Table 1, pilots occupy tones $f_0, f_2, f_4, f_6, f_8, f_{10}, f_{12}$, and f_{14} in a given OFDM symbol for all sectors of a given cell. A cell specific scrambling code may or may not be applied. In some aspects this cell specific scrambling code may be applied as $S(0), S(2), S(4), S(6), S(8), S(10), S(12)$, and $S(14)$. This is then multiplied by a first code $W_1(0), W_1(2), W_1(4), W_1(6), W_1(8), W_1(10), W_1(12)$, and $W_1(14)$ for sector 1, a first code $W_2(0), W_2(2), W_2(4), W_2(6), W_2(8), W_2(10), W_2(12)$, and $W_2(14)$ for sector 2, and a first code $W_3(0), W_3(2), W_3(4), W_3(6), W_3(8), W_3(10), W_3(12)$, and $W_3(14)$. In some aspects, the first and, or, second codes W_1, W_2 , and W_3 may be Walsh or Exponential codes. Also, each of the first code generally has a length that is less than a number of tones utilized for pilot symbols. For example, the codes W_1, W_2 , and W_3 may have a length four, such that each first code is repeated twice in each OFDM symbol for each sector. That is, the first code used to multiply the pilot symbols for subcarriers f_0, f_2, f_4 , and f_6 and the first code used to multiply the pilot symbols for subcarriers f_8, f_{10}, f_{12} , and f_{14} is identical. The received signal at tone i for the user is given by $S(i) (W_1(i)P_N(i)H_1(i) + W_2(i)P_N(i)H_2(i) + W_3(i)P_N(i)H_3(i)) + \text{noise}$, where H_1, H_2 and H_3 are the channels from sectors 1, 2, and 3 respectively.

[00031] Even though W_1, W_2 , and W_3 may be orthogonal or quasi-orthogonal to each other over tones $\{0, 2, 4, 6\}$, the products of any two of $W_1(i)H_1(i), W_2(i)H_2(i)$, and

$W_3(i)H_3(i)$ may not be orthogonal or quasi-orthogonal, if any channel H_1 , H_2 , or H_3 shows significant variations over the tone set $\{0, 2, 4, 6, 8, 10, \text{etc.}\}$. In some cases, because of the channel variation, any two of $W_1(i)H_1(i)$, $W_2(i)H_2(i)$, and $W_3(i)H_3(i)$ actually provide a very high correlation. In this case, there will be no suppression of the interference from pilots of the two sectors. To address such situations the second code P_N may be constant over the length of the first code. In some aspects, the second code would take one pseudorandom value for tones f_0, f_2, f_4 , and f_6 , and another value for tones f_8, f_{10}, f_{12} , and f_{14} . This provides that even if $W_1(i)H_1(i)$, $W_2(i)H_2(i)$, and $W_3(i)H_3(i)$ from two sectors have a high correlation, this correlation has a different phase for different regions of frequency due to the code P_N used, and across different time instances. When an interpolation is performed across frequency or time, the different phases will average out to yield a low overall correlation.

[00032] While the second codes may be constant over the length of the first code, they may vary for other subcarriers that extend beyond the length of the first code in a same sector. It should be noted that the second codes may differ for each sector. Alternatively, the second codes may be the same in each sector, but have a different order in each sector as applied to the different pilot subcarriers in order to make sure no pilot symbols are multiplied by a same second code. Additionally, the sectors may utilize different combinations of some of the same or some of the different codes.

[00033] In some cases, it may be desired that the pilots will have to occupy the same set of tones in different sectors. Therefore, if pilot hopping is used, we have to ensure that it is the same for different sectors.

[00034] Referring to Fig. 3, a multiple access wireless communication system according to another embodiment is illustrated. A multiple access wireless communication system 600 includes multiple cells, e.g. cells 602, 604, and 606. In the embodiment of Fig. 3, each cell 602, 604, and 606 may include multiple sectors, not

shown, which are in communication with mobile stations 620. As discussed above, each cell 602, 604, and 60 may utilize a different cell specific scrambling code to multiply pilot symbols transmitted from its sectors. Each sector may then operate according to any of the aspects and utilize any of the features described herein.

[00035] Referring to Fig. 4, a block diagram of an embodiment of a transmitter system 810 and a receiver system 850 in a MIMO system 800 is illustrated. At transmitter system 810, traffic data for a number of data streams is provided from a data source 812 to transmit (TX) data processor 814. In an embodiment, each data stream is transmitted over a respective transmit antenna. TX data processor 814 formats, codes, and interleaves the traffic data for each data stream based on a particular coding scheme selected for that data stream to provide coded data.

[00036] The coded data for each data stream may be multiplexed with pilot data using OFDM techniques. The pilot data is typically a known data pattern that is processed in a known manner and may be used at the receiver system to estimate the channel response. The multiplexed pilot and coded data for each data stream is then modulated (i.e., symbol mapped) based on a particular modulation scheme (e.g., BPSK, QSPK, M-PSK, or M-QAM) selected for that data stream to provide modulation symbols. The data rate, coding, and modulation for each data stream may be determined by instructions performed on provided by processor 830.

[00037] The modulation symbols for all data streams are then provided to a TX processor 820, which may further process the modulation symbols (e.g., for OFDM). TX processor 820 then provides N_T modulation symbol streams to N_T transmitters (TMTR) 822a through 822t. Each transmitter 822 receives and processes a respective symbol stream to provide one or more analog signals, and further conditions (e.g., amplifies, filters, and upconverts) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. N_T modulated signals from transmitters 822a through 822t are then transmitted from N_T antennas 824a through 824t, respectively.

[00038] At receiver system 850, the transmitted modulated signals are received by N_R antennas 852a through 852r and the received signal from each antenna 852 is provided to a respective receiver (RCVR) 854. Each receiver 854 conditions (e.g., filters, amplifies, and downconverts) a respective received signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

[00039] An RX data processor 860 then receives and processes the N_R received symbol streams from N_R receivers 854 based on a particular receiver processing

technique to provide N_T "detected" symbol streams. The processing by RX data processor 860 is described in further detail below. Each detected symbol stream includes symbols that are estimates of the modulation symbols transmitted for the corresponding data stream. RX data processor 860 then demodulates, deinterleaves, and decodes each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor 818 is complementary to that performed by TX processor 820 and TX data processor 814 at transmitter system 810.

[00040] RX processor 860 may derive an estimate of the channel response between the N_T transmit and N_R receive antennas, e.g., based on the pilot information multiplexed with the traffic data. RX processor 860 may identify the pilot symbols according to pilot patterns stored in memory, e.g. memory 872 that identify the frequency subcarrier and symbol period assigned to each pilot symbol. In addition, the cell scrambling code and sector specific codes, e.g. the second codes with low cross-correlation, may be stored in memory so that they may be utilized by RX processor 860 to multiple the received symbols so that the proper decoding can occur.

[00041] The channel response estimate generated by RX processor 860 may be used to perform space, space/time processing at the receiver, adjust power levels, change modulation rates or schemes, or other actions. RX processor 860 may further estimate the signal-to-noise-and-interference ratios (SNRs) of the detected symbol streams, and possibly other channel characteristics, and provides these quantities to a processor 870. RX data processor 860 or processor 870 may further derive an estimate of the "operating" SNR for the system. Processor 870 then provides channel state information (CSI), which may comprise various types of information regarding the communication link and/or the received data stream. For example, the CSI may comprise only the operating SNR. The CSI is then processed by a TX data processor 878, modulated by a modulator 880, conditioned by transmitters 854a through 854r, and transmitted back to transmitter system 810.

[00042] At transmitter system 810, the modulated signals from receiver system 850 are received by antennas 824, conditioned by receivers 822, demodulated by a demodulator 840, and processed by a RX data processor 842 to recover the CSI reported by the receiver system. The reported CSI is then provided to processor 830 and used to (1) determine the data rates and coding and modulation schemes to be used for the data

streams and (2) generate various controls for TX data processor 814 and TX processor 820. Alternatively, the CSI may be utilized by processor 870 to determine modulation schemes and/or coding rates for transmission, along with other information. This may then be provided to the transmitter which uses this information, which may be quantized, to provide later transmissions to the receiver.

[00043] Processors 830 and 870 direct the operation at the transmitter and receiver systems, respectively. Memories 832 and 872 provide storage for program codes and data used by processors 830 and 870, respectively. The memories 832 and 872 store the cell specific scrambling sequence and the first and second codes with low cross-correlation s.

[00044] Processors 830 and 870 then can utilize the cell specific scrambling sequence and the first and second codes code with low cross-correlation to multiply the pilot symbols for each sector, as appropriate.

[00045] At the receiver, various processing techniques may be used to process the N_R received signals to detect the N_T transmitted symbol streams. These receiver processing techniques may be grouped into two primary categories (i) spatial and space-time receiver processing techniques (which are also referred to as equalization techniques); and (ii) "successive nulling/equalization and interference cancellation" receiver processing technique (which is also referred to as "successive interference cancellation" or "successive cancellation" receiver processing technique).

[00046] While Fig. 4 discusses a MIMO system, the same system may be applied to a multi-input single-output system where multiple transmit antennas, e.g. those on a base station, transmit one or more symbol streams to a single antenna device, e.g. a mobile station. Also, a single output to single input antenna system may be utilized in the same manner as described with respect to Fig. 4.

[00047] Referring to Fig. 5, a flow chart of a method of pilot symbol assignment according to one embodiment is illustrated. A plurality of pilot symbols are generated, block 900. The first code for the sector is then utilized to multiply the samples of the pilot symbols, block 902. A second code for the sector is then applied to the pilot symbols, block 904. In some cases, the second code is constant over the length of the first code. In other cases the second code can be any length and vary over more less of the length of the first code. Further, multiple instances of the first code may be

multiplied by different second codes. The multiplied symbols are then transmitted, block 906.

[00048] Referring to Fig. 6, a block diagram of aspects of portions of a multi-sector base station is illustrated. A base station may include multiple sectors, here for the purposes of illustration only being two. However, any number of sectors may be utilized, e.g. three as depicted in Fig. 1. Each sector includes a means for multiplying pilot symbols with a first code and a second codes, blocks 1000 and 1004 respectively. The codes are different from each other and may both be of a same length, with different second codes being used for each group of pilot symbols multiplied by the first code. A pair of respective transmitters is utilized to transmit the multiplied pilot symbols, blocks 1002 and 1006 respectively.

[00049] The techniques described herein may be implemented by various means. For example, these techniques may be implemented in hardware, software, or a combination thereof. For a hardware implementation, the processing units within a base station or a mobile station 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..

[00050] For a software implementation, the techniques described herein may be implemented with instruction (e.g., procedures, functions, and so on) that may be utilized by one or more processors to perform the functions described herein. The instructions may be stored in memory units and executed by processors. 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.

[00051] 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 may 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.

CLAIMS

1. A wireless communication apparatus, including:
a memory configured to store at least one first sequence of a group of first sequences, having a low cross-correlation with each other, of a first length and at least two second sequences of a group of second sequences, having a low cross-correlation with each other, of a second length that is different than the first length; and
a circuit coupled with the memory, the circuit configured to multiply pilot symbols to be transmitted from each of a plurality of antenna groups utilizing the at least one first sequence and the at least two second sequences.
2. The wireless communication apparatus of claim 1, wherein the memory is further configured to store a scrambling sequence and wherein the processor is further configured to multiply the pilot symbols with the scrambling sequence.
3. The wireless communication apparatus of claim 2, wherein the scrambling sequence includes a single scrambling sequence.
4. The wireless communication apparatus according to any one of claims 1 to 3, wherein the circuit includes a processor.
5. The wireless communication apparatus according to any one of claims 1 to 4, wherein circuit is configured to modulate each pilot symbol with a carrier frequency according to a predetermined pattern.
6. The wireless communication apparatus of claim 5, wherein the predetermined pattern is a same for each antenna group.
7. The wireless communication apparatus of claim 6, wherein the circuit is configured to vary the predetermined pattern over time.
8. The wireless communication apparatus according to any one of claims 1 to 7, wherein each antenna group corresponds to a different sector of a base station.
9. The wireless communication apparatus according to any one of claims 1 to 8, wherein the first sequence is a Walsh code.
10. The wireless communication apparatus according to any one of claims 1 to 9, wherein the group of first sequences are orthogonal codes.
11. The wireless communication apparatus according to any one of claims 1 to 10, wherein the group of second sequences are PN sequences.
12. The wireless communication apparatus according to any one of claims 1 to 10, wherein the group of second sequences are exponential codes.

13. A method of transmitting pilot symbols including:
 - multiplying first pilot symbols for a first antenna group utilizing a first sequence of a group of first sequences, having a low cross-correlation with each other, and at least two second sequences of a group of second sequences, having a low cross-correlation with each other;
 - multiplying second pilot symbols for a second antenna group utilizing a third sequence of the group of first sequences and at least two fourth sequences of the group of second sequences;
 - transmitting the first pilot symbol from the first antenna group; and
 - transmitting the second pilot symbol from the second antenna group.
14. The method of claim 13, further including:
 - multiplying the first pilot symbols and the second pilot symbols by a scrambling sequence;
 - multiplying third pilot symbols for a third antenna group utilizing one of the first group of sequences and at least two second sequence of the group of second sequences;
 - transmitting the third pilot symbol from the third antenna group.
15. The method of claim 13 or 14, further including modulating each pilot symbol with a carrier frequency according to a predetermined pattern.
16. The method of claim 15, wherein the predetermined pattern is a same for each antenna group.
17. The method of claim 16, further including varying the predetermined pattern over time.
18. The method according to any one of claims 13 to 17, wherein each antenna group corresponds to a different sector of a base station.
19. The method according to any one of claims 13 to 18, wherein the first and third orthogonal sequences are Walsh codes.
20. The method according to any one of claims 13 to 19, wherein the group of first sequences are orthogonal codes.
21. The method according to any one of claims 13 to 20, wherein the group of second sequences are PN sequences.
22. The method according to any one of claims 13 to 20, wherein the group of second sequences are exponential codes.
23. A wireless communication apparatus including:

means for multiplying first pilot symbols for a first antenna group utilizing a first sequence of a group of first sequences, having a low cross-correlation with each other and at least two second sequences of a group of second sequences, having a low cross-correlation with each other;

means for multiplying second pilot symbols for a second antenna group utilizing a third sequence of the group of first sequences and at least two fourth sequences of the group of second sequences;

a first transmitter configured to transmit the first pilot symbols from a first antenna group; and

a second transmitter configured to transmit the second pilot symbols from a second antenna group.

24. The apparatus of claim 23, further including means for modulating each pilot symbol with a carrier frequency according to a predetermined pattern.

25. The apparatus of claim 24, further including means for varying the predetermined pattern over time.

26. The apparatus according to any one of claims 23 to 25, wherein each antenna group corresponds to a different sector of a base station.

27. The apparatus according to any one of claims 23 to 26, wherein the first and second sequences are Walsh codes.

28. The apparatus according to any one of claims 23 to 27, wherein the group of first sequences are orthogonal codes.

29. The apparatus according to any one of claims 23 to 28, wherein the group of second sequences are PN sequences.

30. The apparatus according to any one of claims 23 to 28, wherein the group of second sequences are exponential codes.

31. A processor readable medium including instructions thereon that may be utilized by one or more processors, the instructions including:

instructions for multiplying first pilot symbols for a first antenna group utilizing a first sequence of a group of first sequences, having a low cross-correlation with each other and at least two second sequences of a group of second sequences, having a low cross-correlation with each other;

instructions for multiplying second pilot symbols for a second antenna group utilizing a third sequence of the group of first sequences and at least two fourth sequences of the group of second sequences;

instructions for transmitting the first pilot symbols from a first antenna group; and
instructions for transmitting the second pilot symbols from a second antenna group.