EFFICIENT SIGNALING OVER ACCESS CHANNEL

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Patent Application Serial No. 60/590,113, filed July 21, 2004, which is incorporated herein by reference in its entirety.

BACKGROUND

Field

[0002] The invention relates generally to wireless communications, and more specifically to data transmission in a multiple access wireless communication system.

Background

[0003] An access channel is used on the reverse link by an access terminal for initial contact with an access point. The access terminal may initiate an access attempt in order to request dedicated channels, to register, or to perform a handoff, etc. Before initiating an access attempt, the access terminal receives information from the downlink channel in order to determine the strongest signal strength from nearby access points and acquire downlink timing. The access terminal is then able to decode the information transmitted by the given access point on a broadcast channel regarding choice of parameters governing the access terminal's access attempt.

[0004] In some wireless communication systems, an access channel refers both to a probe and message being rendered. In other wireless communication systems, the access channel refers to the probe only. Once the probe is acknowledged, a message governing the access terminal's access attempt is transmitted.

[0005] In an orthogonal frequency division multiple access (OFDMA) system, an access terminal typically separates the access transmission to be transmitted on the access channel into parts, a preamble transmission and a payload transmission. To prevent intra-cell interference due to lack of fine timing on the reverse link during the access preamble transmission, a CDM-based preamble transmission may be time-division-multiplexed with the rest of the transmissions (i.e., traffic, control, and access payload). To access the system, the access terminal then randomly selects one PN

sequence out of a group of PN sequences and sends it as its preamble during the access slot.

[0006] The access point searches for any preambles (i.e., all possible PN sequences) that may have been transmitted during the access slot. Access preamble transmission performance is measured in terms of collision probability, misdetection probability and false alarm probability. Collision probability refers to the probability that a particular pseudo-random (PN) sequence is chosen by more than one access terminal as its preamble in the same access slot. This probability is inversely proportional to the number of preamble sequences available. Misdetection probability refers to the probability that a transmitted PN sequence is not detected by the base station. False alarm probability refers to the probability that an access point erroneously declared that a preamble has been transmitted while no preamble is actually transmitted. This probability increases with the number of preambles available.

[0007] The access point then transmits an acknowledgment for each of the preambles detected. The acknowledgement message may include a PN sequence detected, timing offset correction, and index of the channel for access payload transmission. Access terminal terminals whose PN sequence is acknowledged can then transmit the respective access payload using the assigned resource.

[0008] Because the access point has no prior knowledge of where the access terminal is in the system (i.e. what its power requirements, buffer level, or quality of service may be), the acknowledgement message is broadcasted at a power level high enough such that all access terminals in the given cell can decode the message. The broadcast acknowledgement is inefficient as it requires a disproportionate amount of transmit power and/or frequency bandwidth to close the link. Thus, there is a need to more efficiently send an acknowledgment message to access terminals in a given cell.

SUMMARY

[0009] Embodiments of the invention minimize use of a broadcast acknowledgement channel during its preamble transmission. Embodiments of the invention further addresses how information regarding forward link channel quality can be efficiently signaled over the access channel during access preamble transmission.

In one embodiment, an apparatus and method for transmitting an indicator of channel quality minimizing the use of a broadcast channel is described. A metric of

forward link geometry of observed transmission signals is determined. An indicator of channel quality value is determined as a function of the observed transmission signals. An access sequence is selected, randomly, from one group of a plurality of groups of access sequences, wherein each of the plurality of groups of access sequences correspond to different ranges of channel quality values.

[0010] The metric of forward link geometry may be determined as a function of observed pilot signals, noise, and/or traffic on data channels. The quantity of access sequences in the plurality of groups access sequences are distributed non-uniformly. In an embodiment, the access sequences are distributed to reflect the distribution of access terminals about the access point. In another embodiment, the access sequences are distributed in proportion to the number of access terminals that need a given amount of power needed to send an indicator of acknowledgment to the access terminal.

[0011] In another embodiment, a method of partitioning a plurality of access sequences, is described. A probability distribution of a plurality of access terminals about an access point is determined. The probability distribution is determined as a function of a plurality of access terminals having CQI values within a predetermined ranges. Groups of access sequences are assigned in proportion to the probability distribution. Access sequences can be reassigned as a function of a change in distribution of access terminals about the access point.

[0012] In yet another embodiment, an apparatus and method of transmitting an acknowledgement of a detected access sequence is described. An access sequence is received. The access sequence can be looked-up in a look-up table, stored in memory, to determine at least one attribute of the given access terminal (as a function of the access sequence). The attribute can be information such as a channel quality indicator, a buffer level and a quality of service indicator. Information is then transmitted to the access terminal, where the information is commensurate and consistent with the attribute. Information transmitted may include an indicator of acknowledgment. The indicator of acknowledgment may be transmitted over a shared signalling channel (SSCH).

[0013] Various aspects and embodiments of the invention are described in further detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The features and nature of the present invention will 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:

[0015] FIG. 1 illustrates a block diagram of a transmitter and a receiver;

[0016] FIG. 2 illustrates the access probe structure and the access probe sequence;

[0017] FIG. 3 illustrates a traditional call flow between an access terminal and an access point;

[0018] FIG. 4 illustrates an embodiment of the invention that avoids the use of the broadcast acknowledgement;

[0019] FIG. 5 illustrates a cell partitioned using uniform spacing;

[0020] FIG. 6 illustrates a diagram showing weighted partitioning based on quantized CQI values;

[0021] FIG. 7 illustrates a table stored in memory that partitions the group of access sequences into sub-groups of access sequences based on a variety of factors; and

[0022] FIG. 8 illustrates a process for dynamically allocating access sequences.

DETAILED DESCRIPTION

[0023] 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.

[0024] The techniques described herein for using multiple modulation schemes for a single packet may be used for various communication systems such as an Orthogonal Frequency Division Multiple Access (OFDMA) system, a Code Division Multiple Access (CDMA) system, a Time Division Multiple Access (TDMA) system, a Frequency Division Multiple Access (FDMA) system, an orthogonal frequency division multiplexing (OFDM)-based system, a single-input single-output (SISO) system, a multiple-input multiple-output (MIMO) system, and so on. These techniques may be used for systems that utilize incremental redundancy (IR) and systems that do not utilize IR (e.g., systems that simply repeats data).

[0025] Embodiments of the invention avoid use of a broadcast acknowledgement channel by having the access terminals indicate a parameter, such as forward link channel quality (i.e., CQI), buffer level requirements, quality of service requirements, etc., during its preamble transmission. By having the access terminals indicate forward link channel quality, the access point can transmit each acknowledgment on a channel using an appropriate amount of power for a given access terminal or group of access terminals. In the case of the acknowledgment message being transmitted to a group of access terminals, an acknowledgment message is sent to multiple access terminals who have indicated the same or similar CQI values (within a range). Embodiments of the invention further address how CQI can be efficiently signaled over the access channel during access preamble transmission.

[0026] An "access terminal" refers to a device providing voice and/or data connectivity to a user. An access terminal may be connected to a computing device such as a laptop computer or desktop computer, or it may be a self contained device such as a personal digital assistant. An access terminal can also be called a subscriber station, subscriber unit, mobile station, wireless device, mobile, remote station, remote terminal, user terminal, user agent, or user equipment. A subscriber station may be a cellular telephone, PCS telephone, a cordless telephone, a Session Initiation Protocol (SIP) phone, a wireless local loop (WLL) station, a personal digital assistant (PDA), a handheld device having wireless connection capability, or other processing device connected to a wireless modem.

[0027] An "access point" refers to a device in an access network that communicates over the air-interface, through one or more sectors, with the access terminals or other access points. The access point acts as a router between the access terminal and the rest of the access network, which may include an IP network, by converting received air-interface frames to IP packets. Access points also coordinate the management of attributes for the air interface. An access point may be a base station, sectors of a base station, and/or a combination of a base transceiver station (BTS) and a base station controller (BSC).

[0028] FIG. 1 illustrates a block diagram of a transmitter 210 and a receiver 250 in a wireless communication system 200. At transmitter 210, a TX data processor 220 receives data packets from a data source 212. TX data processor 220 processes (e.g., formats, encodes, partitions, interleaves, and modulates) each data packet in accordance

with a mode selected for that packet and generates up to T blocks of data symbols for the packet. The selected mode for each data packet may indicate (1) the packet size (i.e., the number of information bits for the packet) and (2) the particular combination of code rate and modulation scheme to use for each data symbol block of that packet. A controller 230 provides various controls to data source 212 and TX data processor 220 for each data packet based on the selected mode. TX data processor 220 provides a stream of data symbol blocks (e.g., one block for each frame), where the blocks for each packet may be interlaced with the blocks for one or more other packets.

[0029] A transmitter unit (TMTR) 222 receives the stream of data symbol blocks from TX data processor 220 and generates a modulated signal. Transmitter unit 222 multiplexes in pilot symbols with the data symbols (e.g., using time, frequency, and/or code division multiplexing) and obtains a stream of transmit symbols. Each transmit symbol may be a data symbol, a pilot symbol, or a null symbol having a signal value of zero. Transmitter unit 222 may perform OFDM modulation if OFDM is used by the system. Transmitter unit 222 generates a stream of time-domain samples and further conditions (e.g., converts to analog, frequency upconverts, filters, and amplifies) the sample stream to generate the modulated signal. The modulated signal is then transmitted from an antenna 224 and via a communication channel to receiver 250.

[0030] At receiver 250, the transmitted signal is received by an antenna 252, and the received signal is provided to a receiver unit (RCVR) 254. Receiver unit 254 conditions, digitizes, and pre-processes (e.g., OFDM demodulates) the received signal to obtain received data symbols and received pilot symbols. Receiver unit 254 provides the received data symbols to a detector 256 and the received pilot symbols to a channel estimator 258. Channel estimator 258 processes the received pilot symbols and provides channel estimates (e.g., channel gain estimates and SINR estimates) for the communication channel. Detector 256 performs detection on the received data symbols with the channel estimates and provides detected data symbols to an RX data processor 260. The detected data symbols may be represented by log-likelihood ratios (LLRs) for the code bits used to form the data symbols (as described below) or by other representations. Whenever a new block of detected data symbols is obtained for a given data packet, RX data processor 260 processes (e.g., deinterleaves and decodes) all detected data symbols obtained for that packet and provides a decoded packet to a data

sink 262. RX data processor 260 also checks the decoded packet and provides the packet status, which indicates whether the packet is decoded correctly or in error.

[0031] A controller 270 receives the channel estimates from channel estimator 258 and the packet status from RX data processor 260. Controller 270 selects a mode for the next data packet to be transmitted to receiver 250 based on the channel estimates. Controller 270 also assembles feedback information. The feedback information is processed by a TX data processor 282, further conditioned by a transmitter unit 284, and transmitted via antenna 252 to transmitter 210.

[0032] At transmitter 210, the transmitted signal from receiver 250 is received by antenna 224, conditioned by a receiver unit 242, and further processed by an RX data processor 244 to recover the feedback information sent by receiver 250. Controller 230 obtains the received feedback information, uses the ACK/NAK to control the IR transmission of the packet being sent to receiver 250, and uses the selected mode to process the next data packet to send to receiver 250. Controllers 230 and 270 direct the operation at transmitter 210 and receiver 250, respectively. Memory units 232 and 272 provide storage for program codes and data used by controllers 230 and 270, respectively.

[0033] FIG. 2 illustrates the access probe structure and the access probe sequence 200. In FIG. 2, Ns probe sequences are shown, where each probe sequence has Np probes. The media access control layer (MAC) protocol transmits access probes by instructing the physical layer to transmit a probe. With the instruction, the access channel MAC protocol provides the physical layer with a number of elements, including, but not limited to, the power level, access sequence identification, pilot PN of the sector to which the access probe is to be transmitted, a timing offset field and a control segment field. Each probe in a sequence is transmitted at increasing power until the access terminal receives an access grant. Transmission is aborted if the protocol received a deactivate command, or if a maximum number of probes per sequence have been transmitted. Prior to transmission of the first probe of all probe sequences, the access terminal forms a persistence test which is used to control congestion on the access channel.

[0034] FIG. 3 illustrates a traditional call flow between an access terminal and an access point 300. Access terminal 304 randomly selects a preamble, or PN sequence, out of a group of PN sequences and sends 308 the preamble during the access slot to the access

point 312. Upon receipt, the access point 312 then transmits 316 an access grant, including a broadcast acknowledgement, for each of the preambles detected. This acknowledgement is a broadcasted acknowledgement transmitted at a high enough power such that all of the access terminals in a given cell are able to decode the broadcast acknowledgement. This is deemed necessary because the access point has no prior knowledge where the access terminals are in the system, and thus has no knowledge as to the power level necessary for the access terminal to decode the broadcasted acknowledgement. On receipt of the accent grant 316, access terminal 304 sends 320 the payload as per the defined resources allocated in the access grant.

[0035] The broadcast acknowledgement transmission described above is relatively inefficient as it requires a disproportionate amount of transmit power and/or frequency bandwidth to close the link. FIG 4 illustrates an embodiment 400 that avoids the use of the broadcast acknowledgement. An access terminal observes 408 transmissions from access points. In observing, the access terminal determines the power of transmissions it receives. These observations typically involve determining forward link channel quality from observed acquisition pilot signal transmissions or pilot transmissions as part of a shared signalling channel (SSCH) channel.

[0036] The access terminal 404 then randomly selects a preamble, or access sequence, out of a group of access sequences and sends the preamble 410 to the access point 412. This preamble is transmitted along with some knowledge of forward link channel quality (CQI). CQI information may be transmitted as within the preamble, or appended to it. In another embodiment, an access sequence is randomly chosen out of a plurality of groups of access sequences, where each group of access sequences is designated for a range of CQI values. For example, indications of forward link channel quality may be observed pilot signal power. The observed pilot signal power may be quantized to CQI values based on a predetermined set of values. Thus, a given range of received pilot signal power may correspond to a given CQI value. Accordingly, the access point 412 may determine the CQI of a given access terminal by virtue of the access sequence chosen by the access terminal.

[0037] Because the access terminal sends an indicator of forward link channel quality during its initial access attempt with the access point 412, the access point 412 has the knowledge needed to transmit 416 each acknowledgement on a channel using an appropriate amount of power for the designated access terminal 404. In an

embodiment, the acknowledgment message may be sent to a group of access terminals having the same or similar CQI values. This may be through use of the SSCH. Thus, based on the power level needed for the access terminal to successfully receive the transmission, the access point sends the acknowledgement message in the appropriate section of the SSCH message.

[0038] In addition to CQI information, the access terminal may send other information of interest to the access point during the initial access phase. For example, the access terminal may send a buffer level indicator, indicating the amount of data the access terminal intends to send to the access point. With such knowledge, the access point is able to appropriately dimension initial resource assignments.

[0039] The access terminal may also send information regarding priority groups or quality of service. This information may be used to prioritize access terminals in the event of limited access point capability or system overload.

[0040] Upon receipt of the access grant message by the access terminal, the access terminal 404 sends 420 payload as per the resources defined in the access grant message. By receiving additional information during the initial access phase, the access point will be able to take advantage of knowing the CQI, buffer level and quality of service information as part of the access grant message.

[0041] FIG. 5 illustrates a cell 500 partitioned using uniform spacing. The cell is divided into a number of regions R, wherein each region is defined by having a probability of observed metrics within a given range. In an embodiment, observations of forward link geometry are used. For example, metrics such as C/I, where C is the received pilot power and I is the observed noise, may be used. Also, C/(C+I) may be used. In other words, some measure that utilizes observed signal power and noise is used. These observed metrics correspond to given CQI values, or value ranges, which thus define the region. For example, Region R_1 defines a Region having CQI values corresponding to power and/or noise levels greater than P_1. Region R_2 defines a region having CQI values corresponding to power and/or noise levels such that $P_2 > R_2 > P_1$. Similarly, Region R_3 defines a Region having CQI values corresponding to power and/or noise levels such that $P_3 > R_3 > P_2$, and so on. Region R_{N-1} has CQI values corresponding to power and/or noise levels such that they fall in the range of $P_x > R_{N-1} > P_y$. Similarly, Region R_N has CQI values corresponding to power and/or noise levels observed $< P_x$.

[0042] Theoretically, by choosing to transmit one of N possible preamble sequences, up to $\log_2(N)$ bits of information may be conveyed. For example, when $N = 1024$, as many as $\log_2(1024) = 10$ bits may be conveyed. Thus, by choosing which preamble sequence to transmit, it is possible for user dependent information to be embedded as part of the preamble transmission.

[0043] A commonly used technique is to partition then N preamble sequences into M distinct sets, labeled $\{1,2,\cdots,M\}$To signal one of $\log_2(M)$ possibilities (i.e., $\log_2(M)$ bits), a sequence in an appropriate set is chosen and transmitted. For instance, to signal message index $k \in \{1,2,\cdots, M\}$, a sequence in the k^{th} set is (randomly) chosen and transmitted. Assuming correct detection at the receiver, the transmitted information (i.e., the $\log_2(M)$ -bit message) can be obtained based on the index of the set that the received sequence belongs to.

[0044] In a uniform partitioning strategy, where the N preamble sequences are uniformly partitioned into M groups (i.e., each group contains N/M sequences). Based on the measured CQI value, one of the preamble sequences from an appropriate set is selected and transmitted. The collision probability, then, depends on the mapping/quantization of the measured CQI and the number of simultaneous access attempts.

[0045] This can be illustrated by considering a simple 2-level quantization of CQI (i.e.,M=2), with $\Pr(M(\text{CQI})=1)=\alpha$ and $\Pr(M(\text{CQI})=1)=\alpha$, where $M(x)$ is a quantization function mapping the measured CQI value into one of the two levels.

[0046] With uniform access sequence partitioning, the N preamble sequences are partitioned into two sets with N/2 sequences in each set. As by example, assume that there are two simultaneous access attempts (i.e., exactly two access terminals are trying to access the system in each access slot). The collision probability is given by

$$\alpha^2 \frac{1}{\left(\frac{N}{2}\right)} + (1-\alpha)^2 \frac{1}{\left(\frac{N}{2}\right)}.$$

[0047] With probability α^2, the two access terminals wish to send $M=1$(i.e., they both have quantized CQI level = 1). Since there are N/2 preamble sequences to choose from in the first set, the collision probability (given that both access terminals choose their sequence from this set) is 1/(N/2). Following the same logic, the collision probability for the other set can be derived.

[0048] Thus, the overall collision probability depends on the parameter α and number of simultaneous access attempts. The collision probability can be as high as $2/N$ (α =0,1) or as low as $1/N$ (α = 0.5). Thus, the best choice of α in this case is α =0.5. However, it is unclear whether the CQI quantization function that results in α =0.5 is a desirable function.

[0049] The access point will transmit the acknowledgment channel at the power level required to close the link as indicated by the CQI level. In this example, with probability α, the access point has to transmit at the power corresponding to that of a broadcast channel and with probability 1-α, the access point can transmit at some lower power. Thus, with α = 0.5, half the time the access point has to broadcast the acknowledgment channel. On the other hand, by choosing α = 0.5, the access point is forced to broadcast the acknowledgement channel less frequently but incurring an increase in the transmit power in the remaining of the time and higher overall collision probability.

[0050] FIG. 6 illustrates a diagram showing weighted partitioning 600 based on quantized CQI values. The region is partitioned into various regions that are not of a uniform space, but are rather partitioned based on quantized CQI values that are weighted. By weighting the regions, additional preamble sequences are available in regions that have a higher probability of access terminals being in that region (i.e., a higher mass function). For example, regions 604, 608, and 612 are larger regions that may correspond to having a larger number of access sequences available. Conversely, regions 616 and 620 are smaller regions that may indicate smaller quantities of users present and thus fewer access sequences available. Thus, the regions may be partitioned having some prior knowledge as to the distribution of C/I or received power in a specified range in a given cell. It is contemplated that geographic regions may not always represent concentrations of users within given CQI ranges. Rather, the graphical representations of non-uniform spacing is to indicate the non-uniform distribution of access sequences through a given cell region.

[0051] In an embodiment, the probability distribution of access terminals within the cell may be dynamic based on the distribution of access terminals over time. Accordingly, certain partitioned regions may be larger or smaller based on the absence or presence of access terminals at a given time of the day, or otherwise adjusted as a function of the concentration of access terminals present in a given CQI region.

[0052] Thus, the sequences available for initial access are divided into *N* number of partitions. The access terminal determines the partition to be used for the access attempt based on at least the observed pilot power and buffer level. It is contemplated that the partition may also be determined on a number of other factors, such as packet size, traffic type, bandwidth request, or quality of service. Once the partition is determined, the access terminals select the sequence ID using a uniform probability over that partition. Of the available sequences for access, a subset of sequences is reserved for active set operations, and another subset of sequences are available for initial access. In one embodiment, sequences 0, 1 and 2 are reserved for active set operations, and sequences 3 through the total number of access sequences are available for initial access.

[0053] The size of each partition is determined by the access sequence partition field in the system information bock. This is typically part of the sector parameter. A particular partition number *N* comprises sequence identifiers ranging from a lower threshold, partition *N* lower, to an upper threshold, partition *N* upper. Both thresholds are determined using the partitions size, partially provided in table 1 below:

Access Sequence Partition	Partition N Size (N from 1 to 8)							
	1	2	3	4	5	6	7	8
00000	0	0	0	0	0	0	0	0
00001	S2	S2	S2	S2	S2	S2	S2	S2
00010	S3	S3	S	S1	S1	S1	S1	S1
00011	S1	S1	S1	S3	S3	S3	S1	S1
00100	S1	S1	S1	S1	S1	S1	S3	S3
00101	S3	S1	S1	S3	S1	S1	S3	S1
00101	S1	S3	S1	S1	S3	S1	S1	S3
00110	S1	S1	S3	S1	S1	S3	S1	S1
00111	S3	S3	S1	S3	S1	S1	S1	S1
01000	S1	S1	S1	S3	S3	S1	S3	S1

[0054] Thus, in this embodiment the access terminal selects its pilot level based on the ratio, measured in decibels, of the acquisition pilot power from the sector where the access attempt is being made to the total power received in the acquisition channel time slot. The pilot threshold values are determined based on the pilot strength segmentation field of the system information message.

[0055] Embodiments describe a technique whereby the access sequence space is partitioned according to the statistics of the quantized CQI. More precisely,

$$p = [p_1 \quad p_2 \quad \cdots \quad p_M]$$

is the probability mass function of the quantized CQI values, where

$$\Pr(CQI = 1) = p_1, \Pr(CQI = 2) = p_2, \cdots, \Pr(CQI = M) = p_M).$$

The access sequence space is then partitioned to have a similar probability mass function. That is, the ratio of the number of access sequences in each set to the total number of access sequences should be proportional, such that

[0056] $$p = [p_1 \quad p_2 \quad \cdots \quad p_M] (\text{i.e.,} \left(\frac{N_1}{N}, \quad \frac{N_2}{N}, \quad \cdots, \quad \frac{N_M}{N} \right) = (p_1 \quad p_2 \quad \cdots \quad p_M),$$

where N_k is the number of access sequences in set $K \in \{1,2,\cdots,M\}$

[0057] In the example describing the 2-level CQI quantization function yields the following:

$$\Pr(M(CQI) = 1) = \alpha \text{ and } \Pr(M(CQI) = 2) = 1 - \alpha$$

The number of access sequences in each set is, therefore, $(\alpha)N$ and $(1-\alpha)$N, respectively. The resulting collision probability is

$$\alpha^2 \frac{1}{(\alpha N)} + (1-\alpha)^2 \frac{1}{((1-\alpha)N)} = \frac{\alpha}{N} + \frac{(1-\alpha)}{N} = \frac{1}{N},$$

which is the smallest collision probability possible.

[0058] For a more general setting with M possible CQI levels and U simultaneous attempts, the analytical expression of the collision probability becomes more complex.

[0059] In another example, consider M=6 ,U=8 , and N=1024. Assume that the CQI values are quantized in the step of 4-5 dB. The quantized CQI values are given by [-3, 1, 5, 10, 15, 20] dB with the following probability mass function [0.05, 0.25, 0.25 0.20 0.15 0.10]. That is, 5% of the time, users will report CQI values lower than -3 dB, 25% of the time with CQI values between -3 and 1 dB, and so on. The access point can then adjust the power for the acknowledgment channel based on the reported CQI.

[0060] Using the proposed access sequence partitioning technique, the resulting collision probability is approximately 2.5%. The collision probability using uniform access sequence partitioning compared is 3.3%. However, to get a similar collision probability when a uniform access sequence partitioning is used, the total number of sequences has to be increased by 25% to 1280. Accordingly, a larger number of access

sequences to search translates directly to higher complexity and higher false alarm probability.

[0061] This partitioning strategy can also be used when signaling other information such as packet size, traffic type, and bandwidth request over the access channel. This is particularly useful when the access channel (the preamble portion) is used as a means for users to get back into the system or to request resources. If information regarding the statistics of information to be conveyed is known (e.g., percentage of times a certain traffic connection (http, ftp, SMS) is requested or how much bandwidth is often required, etc.), then this information can be used in determining the partition of the access preamble sequence space.

[0062] FIG. 7 illustrates a table 700 stored in memory that partitions the group of access sequences into sub-groups of access sequences based on a variety of factors. Factors include CQI ranges, buffer level, quality of service, packet size, frequency bandwidth request, or other factors. The quantity of access sequences in a given sub-group may be initially determined on statistics maintained of past concentration of users in the given cell as a function of the factors being considered. Thus,. each cell may have a predetermined mass distribution of access sequences for combinations of the various factors. In so doing, the collision probability of multiple users selecting the same access sequence is minimized.

[0063] In an embodiment, the quantity of access sequences assigned to various combinations of factors may dynamically change based on changes in the composition of users needs. Thus, if a higher quantity of users migrate to a region with a CQI within a given range and a buffer level of a certain amount, and other various factors, that region may be assigned additional access sequences. Dynamic allocation of access sequences thus mimics an optimal scenario whereby the collision probability is minimized.

[0064] FIG. 8 illustrates such a process 800. Initial partitions are set 804, thereby partitioning the plurality of access sequences into a number of groups of access sequences. These groups may be based on ranges of CQI values. In an embodiment, the initial set may be based on uniform distribution of access sequences. In another embodiment, the initial partition sizes may be based on historical data. A counter 808 counts the access attempts in each subset. The counter can keep track of the access attempts over time to determine if there are patterns of varying heavy or light usage.

Based on this access attempts over time, the expected value of access attempts in given subsets may be updated 812. The expected value may be represented by the following equation:

$$E_m := (1-\beta)E_m + \beta\, a_m(a_m - 1)$$

where E_m is the expected value, a_m represents the quantity of access sequences in a given subset, and β is the forgetting factor. The forgetting factor computes an average recursively, that gives a larger weight to more recent data and a lesser weight to less recent data.

[0065] Based on the new expected value, the new subset size may be determined 816. In an embodiment, the subset size is determined by the following equation:

$$N_m = N\frac{\sqrt{E_m}}{\sum_{k=1}^{M}\sqrt{E_k}}, \quad 1 \le m \le M$$

where N_m is the new subset size, E_k is the "old" expectation value of the k^{th} subset, m is the given subset out of M total subsets.

[0066] A determination is made 820 as to whether newly determined subset size is substantially different than the previously set subset size. The threshold for what constitutes "substantially different" is configurable. If a determination is made that the newly determined subset size is substantially different 824, then the subset sizes are reset. If not (828), the current subset sizes are maintained 832.

[0067] The various aspects and features of the present invention have been described above with regard to specific embodiments. As used herein, the terms 'comprises,' 'comprising,' or any other variations thereof, are intended to be interpreted as non-exclusively including the elements or limitations which follow those terms. Accordingly, a system, method, or other embodiment that comprises a set of elements is not limited to only those elements, and may include other elements not expressly listed or inherent to the claimed embodiment.

[0068] While the present invention has been described with reference to particular embodiments, it should be understood that the embodiments are illustrative and that the scope of the invention is not limited to these embodiments. Many variations, modifications, additions and improvements to the embodiments described above are possible. It is contemplated that these variations, modifications, additions and

improvements fall within the scope of the invention as detailed within the following claims.

CLAIMS

1. In a wireless communication system, a method of determining an indicator of channel quality, the method comprising:

determining a metric of an observed transmission;

determining an estimate of channel quality based on at least the metric of the observed transmission; and

selecting an access sequence, randomly, from one group of a plurality of groups of access sequences, wherein the plurality of groups of access sequences correspond to different ranges of channel quality values, and wherein the selected access sequence is from the group of the plurality of groups corresponding to the determined estimate of channel quality.

2. The method set forth in claim 1, wherein determining the metric further comprises determining the power of an observed pilot signal.

3. The method set forth in claim 1, wherein determining the estimate of channel quality further comprises determining the ratio of received pilot power to noise.

4. The method set forth in claim 1, wherein determining the estimate of channel quality further comprises determining the ratio of received pilot power to the sum of received pilot and power and noise.

5. The method set forth in claim 1, wherein the plurality of access sequences in the plurality of groups of access sequences are distributed non-uniformly.

6. The method set forth in claim 1, further comprising transmitting the selected access sequence.

7. The method set forth in claim 6, wherein transmitting further comprises transmitting in accordance with a Frequency Division Multiplex (FDM) scheme.

8. The method set forth in claim 6, wherein transmitting further comprises transmitting in accordance with a Code Division Multiplex (CDM) scheme.

9. The method set forth in claim 6, wherein the act of transmitting further comprises transmitting in accordance with an Orthogonal Frequency Division Multiple Access (OFDMA) scheme.

10. The method set forth in claim 1, wherein selecting further comprises selecting information indicative of access terminal requirements.

11. The method set forth in claim 10, wherein selecting information further comprises selecting information buffer level needs, quality of service requirements, a forward-link channel quality indicator.

12. In a wireless communication system, an apparatus to determine an indicator of channel quality, the apparatus comprising:

a receiver configured to receive observed transmissions;

a processor configured to determine a metric of the observed transmission, and to determine an estimate of channel quality as a function of at least the metric of the observed transmission;

a memory element configured to store a plurality of groups of access sequences, wherein the plurality of groups of access sequences correspond to different ranges of channel quality values; and

a selector configured to select an access sequence, randomly, from the group of the plurality of groups corresponding to the determined channel quality value.

13. The apparatus set forth in claim 12, the processor further comprises determining the ratio of received pilot power to noise.

14. The apparatus set forth in claim 12, the plurality of access sequences in the plurality of groups of access sequences are distributed non-uniformly.

15. The apparatus set forth in claim 12, further comprising a transmitter configured to transmit the selected access sequence.

16. The apparatus set forth in claim 15, wherein the transmitter is further configured to transmit in accordance with a Frequency Division Multiplex (FDM) scheme.

17. The apparatus set forth in claim 15, wherein the transmitter is further configured to transmit in accordance with a Code Division Multiplex (CDM) scheme.

18. The apparatus set forth in claim 14, wherein the transmitter is further configured to transmit in accordance with an Orthogonal Frequency Division Multiple Access (OFDMA) scheme.

19. The apparatus set forth in claim 11, wherein the selector is further configured to select information indicative of access terminal requirements.

20. The apparatus set forth in claim 19, wherein the information indicative of access terminal requirements comprises buffer level, quality of service requirements, a forward-link channel quality indicator.

21. In a wireless communication system, an apparatus for determining an indicator of channel quality, the means comprising:

means for determining a power level of an observed transmission;

means for determining a CQI value as a function of the power level of the observed transmission; and

means for selecting an access sequence, randomly, from one group of a plurality of groups of access sequences, wherein the plurality of groups of access sequences correspond to different ranges of CQI values, and wherein the selected access sequence is from the group of the plurality of groups corresponding to the determined CQI value.

22. The apparatus set forth in claim 21, wherein means for determining a power level further comprises means for determining the power level of an observed pilot signal.

23. The apparatus set forth in claim 21, wherein the plurality of access sequences in the plurality of groups of access sequences are distributed non-uniformly.

24. The apparatus set forth in claim 21, further comprising means for transmitting the selected access sequence.

25. The apparatus set forth in claim 24, wherein means for transmitting further comprises means for transmitting in accordance with a Frequency Division Multiplex (FDM) scheme.

26. The apparatus set forth in claim 24, wherein means for transmitting further comprises means for transmitting in accordance with a Code Division Multiplex (CDM) scheme.

27. The apparatus set forth in claim 24, wherein means for transmitting further comprises transmitting in accordance with an Orthogonal Frequency Division Multiplex (OFDM) scheme.

28. The apparatus set forth in claim 24, wherein the means for transmitting further comprises means for transmitting in accordance with an Orthogonal Frequency Division Multiple Access (OFDMA) scheme.

29. The apparatus set forth in claim 21, wherein selecting further comprises means for selecting information indicative of access terminal requirements.

30. The apparatus set forth in claim 29, wherein means for selecting information further comprises selecting information regarding buffer level needs, quality of service requirements, and/or a forward-link channel quality indicator.

31. In a wireless communication system, a method of transmitting information regarding access terminal needs, the method comprising:

determining a received power level of an observed pilot signal;

determining a CQI value as a function of the received power level; and

selecting an access sequence, randomly, from one group of a plurality of groups of access sequences, wherein the plurality of groups of access sequences correspond to a plurality of predetermined factors.

32. The method set forth in claim 31, wherein the predetermined factors include on or more of ranges of CQI values, ranges of buffer levels, packet size, traffic type, frequency bandwidth request and ranges of quality of service indicators.

33. In a wireless communication system, a method of communicating a channel quality indicator (CQI), the method comprising:

determining a power level of an observed pilot signal;

determining a CQI value as a function of the power level of the observed pilot signal;

selecting an access sequence, randomly, from one group of a plurality of groups of access sequences, wherein the plurality of groups of access sequences correspond different the CQI values;

appending the CQI value to the selected access sequence; and

transmitting the access sequence and CQI value.

34. A method of partitioning a plurality of access sequences, the method comprising:

determining a probability distribution of a plurality of access terminals about an access point, wherein the probability distribution is a function of a plurality of access terminals being partitioned into a plurality of sub-groups, wherein each sub-group is categorized as a function of CQI values within a predetermined range; and

assigning groups of access sequences in proportion to the probability distribution.

35. The method set forth in claim 34, further comprising reassigning access sequences as a function of a change in distribution of access terminals about the access point.

36. In a wireless communication system, an apparatus for transmitting information regarding access terminal needs, the apparatus comprising:

means for determining a received power level of an observed pilot signal;

means for determining a CQI value as a function of the received power level; and

means for selecting an access sequence, randomly, from one group of a plurality of groups of access sequences, wherein the plurality of groups of access sequences correspond to a plurality of predetermined factors.

37. The apparatus set forth in claim 31, wherein the predetermined factors include on or more of ranges of CQI values, ranges of buffer levels, packet size, traffic type, frequency bandwidth request and ranges of quality of service indicators.

38. In a wireless communication system, an apparatus for communicating a channel quality indicator (CQI), the apparatus comprising:

means for determining a power level of an observed pilot signal;

means for determining a CQI value as a function of the power level of the observed pilot signal;

means for selecting an access sequence, randomly, from one group of a plurality of groups of access sequences, wherein the plurality of groups of access sequences correspond different the CQI values;

means for appending the CQI value to the selected access sequence; and

means for transmitting the access sequence and CQI value.

39. An apparatus for partitioning a plurality of access sequences, the apparatus comprising:

means for determining a probability distribution of a plurality of access terminals about an access point, wherein the probability distribution is a function of a plurality of access terminals being partitioned into a plurality of sub-groups, wherein each sub-group is categorized as a function of CQI values within a predetermined range; and

means for assigning groups of access sequences in proportion to the probability distribution.

40. The apparatus set forth in claim 34, further comprising means for reassigning access sequences as a function of a change in distribution of access terminals about the access point.

41. In a wireless communication system, a method of transmitting an acknowledgement of a detected access sequence, the method comprising:

receiving an access sequence;

determining at least one attribute of a given access terminal as a function of the access sequence; and

transmitting information commensurate with the at least one attribute.

42. The method set forth in claim 41, wherein the attribute is at least one of a channel quality indicator, a buffer level indicator, a priority indicator and a quality of service indicator.

43. The method set forth in claim 41, wherein the transmitting information further comprises transmitting an indictor of acknowledgment.

44. The method set forth in claim 43, further comprising transmitting an indicator of acknowledgment over a shared signaling channel (SSCH).

45. The method set forth in claim 44, wherein the indicator of acknowledgment is included in a particular section of a shared signaling channel (SSCH), wherein the section of the SSCH is partitioned on a basis of the transmission power needed for the indicator of acknowledgment to be successfully received.

46. In a wireless communication system, a memory medium comprising *N* dimensions, wherein at least one of the dimensions comprises data correlating access sequences with indicators of channel quality.

47. The memory medium of claim 46, further comprising a dimension comprising data correlating access sequences with buffer level.

48. The memory medium of claim 46, further comprising a dimension comprising data correlating access sequences with packet size.

49. The memory medium of claim 46, further comprising a dimension comprising data correlating access sequences with traffic type.

50. The memory medium of claim 46, further comprising a dimension comprising data correlating access sequences with quality of service indicators.

51. The memory medium of claim 46, further comprising a dimension comprising data correlating access sequences with requests regarding frequency bandwidth.

52. In a wireless communication system, an apparatus for transmitting an acknowledgement of a detected access sequence, the apparatus comprising:

means for receiving an access sequence;

means for determining at least one attribute of a given access terminal as a function of the access sequence; and

means for transmitting information commensurate with the at least one attribute.

53. The apparatus set forth in claim 52, wherein the attribute is at least one of a channel quality indicator, a buffer level indicator, a priority indicator and a quality of service indicator.

54. The apparatus set forth in claim 52, wherein the means for transmitting information further comprises transmitting an indictor of acknowledgment.

55. The apparatus set forth in claim 54, further comprising means for transmitting an indicator of acknowledgment over a shared signaling channel (SSCH).

56. The apparatus set forth in claim 54, wherein the indicator of acknowledgment is included in a particular section of a shared signaling channel (SSCH), wherein the section of the SSCH is partitioned on a basis of the transmission power needed for the indicator of acknowledgment to be successfully received.