(12) STANDARD PATENT (11) Application No. AU 2011253750 C1
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Method and apparatus for feedback overhead reduction in wireless communications

(51) International Patent Classification(s)
H04W 72/04 (2009.01) ***H04W 28/06*** (2009.01)

(21) Application No: **2011253750** (22) Date of Filing: **2011.11.30**

(43) Publication Date: **2011.12.22**
(43) Publication Journal Date: **2011.12.22**
(44) Accepted Journal Date: **2014.10.23**
(44) Amended Journal Date: **2015.04.30**

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(56) Related Art
WO 2006/105005
WO 2006/105308
US 2005/0003782

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ABSTRACT

A method and apparatus for reducing feedback transmission overhead in wireless communications. Averaging, composition, or both are used to reduce a number of bits needed for transmission of channel quality information.

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P001
Section 29
Regulation 3.2(2)

AUSTRALIA

Patents Act 1990

ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT

Application Number:

Lodged:

Invention Title: Method and apparatus for feedback overhead reduction in wireless communications

The following statement is a full description of this invention, including the best method of performing it known to us:

P111AHAU/0710

METHOD AND APPARATUS FOR FEEDBACK OVERHEAD REDUCTION IN WIRELESS COMMUNICATIONS

FIELD OF THE INVENTION

This application is related to wireless communications.

BACKGROUND TO THE INVENTION

Minimizing signalling overhead is desirable in wireless communications. This applies in particular to feedback transmissions and, in particular to feedback of channel quality, as measured by, for example, a signal-to-noise ratio or other channel quality index. A mobile unit, for example, may determine the quality of one or more channels and transmit this information to a base station, enabling the base station to select a set of best channels for communication at a given time.

In previously proposed schemes called "best-M" schemes, overhead for quality information feedback is reduced by reporting quality measures for a number M out of all transmission bands having the best quality.

SUMMARY

A method and apparatus for feedback overhead reduction in wireless communications are disclosed. Averaging, compression, or both are used to reduce a number of bits, or overhead, needed for transmission of channel quality information. The method disclosed here requires fewer transmitted bits than some previously proposed "best-M" schemes.

In one aspect the present invention provides a wireless transmit/receive unit (WTRU) including:

a processor configured to determine a channel quality index (CQI) for a first transmission layer of each of N groups of frequency resource blocks;

wherein the N groups of frequency resource blocks divide a downlink bandwidth; and

wherein the processor is configured to transmit each of the N channel quality indices in a different reporting transmission time interval (TTI); and

wherein the processor is further configured to transmit, along with each of the N channel quality indices, a channel quality index corresponding to at least a second transmission layer for the corresponding frequency resource blocks.

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In another aspect the present invention provides a method including:

determining, by a wireless transmit/receive unit (WTRU), a channel quality index (CQI) for a first transmission layer of each of N groups of frequency resource blocks, wherein the N groups of frequency resource blocks divide a downlink bandwidth; and

transmitting, by the WTRU, each of the N channel quality indices in different reporting transmission time intervals; and

transmitting, along with each of the N channel quality indices, information indicating a channel quality index corresponding to at least a second layer for the corresponding frequency resource blocks.

In a further aspect the present invention provides a wireless network node including:

a processor and a receiver configured to receive channel quality index (CQI) information from one wireless transmit/receive unit (WTRU) in N reporting transmission time intervals (TTIs);

wherein the CQI information in each of the N reporting TTIs corresponds to a first transmission layer of a respective one of N groups of frequency resource blocks;

wherein the N groups of frequency resource blocks divide a downlink bandwidth; and

wherein the processor is configured to receive, in each of the NTTIs, information indicating a channel quality index corresponding to at least a second layer for the corresponding frequency resource blocks.

BRIEF DESCRIPTION OF THE DRAWINGS

A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

Figure 1 is a flowchart of a first embodiment of a method for overhead reduction;

[0012] Figure 2 is a flowchart of a second embodiment of a method for overhead reduction;

[0013] Figure 3 is an example of a third embodiment of a method for overhead reduction;

[0014] Figure 4 shows an alternative example of the second embodiment; and

[0015] Figure 5 shows an example of a wireless transmit/receive unit configured for implementing any of the embodiments of the method.

[0016] DETAILED DESCRIPTION

[0017] When referred to hereafter, the terminology "wireless transmit/receive unit (WTRU)" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, or any other type of user device capable of operating in a wireless environment. When referred to hereafter, the terminology "base station" includes but is not limited to a Node-B, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

[0018] Figure 1 is a flowchart showing a first embodiment of a method 100 for reducing feedback transmission overhead in wireless communications, which shall be designated a regular hybrid best-M scheme. As is known to those skilled in the art, a bandwidth of a communication channel is typically divided into a number of sub-bands. The method 100 begins with determining a quality of a signal in each sub-band 105. The measure of quality is a pre-defined quality metric, such as a signal-to-noise ratio or a channel quality index (CQI). A number M of sub-bands having the best values of the metric are selected 110. The number M is less than the total number of sub-bands.

[0019] The M selected sub-bands are preferably grouped into a number Q of groups in step 120. The number of groups Q is preferably at least 2 and less than the selected number of sub-bands M. As Q decreases, the number of bits (overhead) needed to report the quality metrics decreases, but the accuracy (resolution) of reporting which bands are in the best M also decreases. The value of Q is therefore preferably chosen to optimize this trade-off. An example optimization is to choose Q such that no more than one group contains exactly one sub-band. Once the sub-bands are grouped, an average of the metrics of the sub-bands in each of the Q groups is determined in step 130. The result is Q primary averages. A single average of metrics of the sub-bands not included in the M best sub-bands is determined (step140). This average is designated as a secondary average. The Q primary averages and one secondary average are transmitted in step 150. Locations of the M best sub-bands and the Q groups within the bandwidth are transmitted (step 160).

[0020] In a specific example, the averages and locations are transmitted from a wireless transmit/receive unit (WTRU) to a base station (BS) enabling the BS to optimize communications by using only higher quality sub-bands. More generally, the averages may be transmitted to any wireless receiver.

[0021] Several alternatives may be used to transmit the locations in order to make the receiver aware of which sub-bands are included in the best M and which of those belong to each of the Q groups. In one alternative the averages may be transmitted in a pre-determined order, as described further below. In another alternative a set of labels may be transmitted. As an example of the latter, consider the case Q=2. One label may be transmitted to indicate locations within the bandwidth of the M best quality sub-bands. A second label may be transmitted indicating which of the M sub-bands belong to one of the two groups. By default, the remaining bands are known to belong to the other group. In general, in this scheme, Q locations are transmitted. Since Q is less than M, the number of bits (overhead) used to transmit useful sub-band quality information may be less than that required if quality information for all M bands is transmitted -- the so-called best M individual reporting scheme.

[0022] An alternative scheme within the first embodiment, designated hybrid best-M differential, may further reduce the required overhead. In this alternative, as in the hybrid best M scheme described above, Q location indices are transmitted, one for the best-M sub-bands and Q-1 for the bands in Q-1 of the

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Q groups. In this scheme, however, the Q groups are ordered, and only one primary average quality metric value for a first of the Q groups is reported. The remaining Q-1 primary averages are each reported as a difference between each average and the average preceding it in the order. The secondary average is reported as the difference between the secondary average and the last of the primary averages.

[0023] As an example of the differential scheme consider again the case Q=2. In this case, averages transmitted are:

[0024] a) one primary average for a first of the two groups,

[0025] b) the difference between the primary average of the second group and that of the first group, and

[0026] c) the difference between the secondary average and the primary average of the second group.

[0027] Compared with the regular hybrid best-M scheme, described above, items a) and b) together save at least two more bits and item c) saves at least one more bit.

[0028] Figure 2 is a flowchart showing a second embodiment of a method 200 for reducing feedback transmission overhead. In this embodiment a compression transform is used to reduce the overhead.

[0029] Similar to the first embodiment of Figure 1, a quality metric is determined for each sub-band in step 205 and the M sub-bands with the best quality metric are selected in step 210. An average of the metrics for the sub-bands not among the best M is determined (step 240). The M metrics and the average are compressed in step 250 and the compressed values are transmitted (step 260). The compression reduces the required transmission overhead.

[0030] A particular example of the use of a compression transform is now described. The M metric values and the average may be arranged as components of a vector. The order of the components of the vector indicates which of the best M sub-bands corresponds to metric value and which component is the average. For example, for M=5 an eight-component vector y may be defined as

$$y = [CQI_1 \;\; CQI_2 \;\; CQI_3 \;\; CQI_4 \;\; CQI_5 \;\; CQI_{avg} \;\; 0 \;\; 0]$$

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where $CQI_1 - CQI_5$ are the quality metric values for sub-bands 1-5 respectively, and CQI_{avg} is the average of the metrics for sub-bands not included in the M best. The two 0 components are explained below.

[0031] The information contained in the vector y is now compressed by a compression transform represented by matrix W. The compression may be represented as matrix multiplication to produce a compressed vector y3:

$$y3 = yW.$$

The components of the compressed vector y3 are quantized and transmitted.

[0032] As a specific example, the compression transform may be a Haar transform. Haar transforms, which are particular types of wavelet transforms, have been used for such applications as image compression. A Haar transform may reduce transmission overhead by shifting weight of the vector components into one component.

[0033] For the example of the M=5 vector above, a suitable Haar transform may be carried out with the matrix

[0034] $$W = \begin{bmatrix} 1/8 & 1/8 & 1/4 & 0 & 1/2 & 0 & 0 & 0 \\ 1/8 & 1/8 & 1/4 & 0 & -1/2 & 0 & 0 & 0 \\ 1/8 & 1/8 & -1/4 & 0 & 0 & 1/2 & 0 & 0 \\ 1/8 & 1/8 & -1/4 & 0 & 0 & -1/2 & 0 & 0 \\ 1/8 & -1/8 & 0 & 1/4 & 0 & 0 & 1/2 & 0 \\ 1/8 & -1/8 & 0 & 1/4 & 0 & 0 & -1/2 & 0 \\ 1/8 & -1/8 & 0 & -1/4 & 0 & 0 & 0 & 1/2 \\ 1/8 & -1/8 & 0 & -1/4 & 0 & 0 & 0 & -1/2 \end{bmatrix}.$$

This Haar transform is invertible and the uncompressed vector y may be recovered without loss by inverting the process, as represented by $y=y_3F$, where

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$$\mathbf{F} = \mathbf{W}^{-1} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & -1 & -1 \\ 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 \end{bmatrix}.$$

[0035] Note that for this example, the two zeros in the vector y result in the last component of the compressed vector y3 being zero. This last component can therefore be removed before transmitting without loss of information.

[0036] As an alternative, the components of vector y may rearranged as follows:

$$y' = [CQI_1\ \ CQI_2\ \ CQI_3\ \ CQI_4\ \ CQI_5\ \ 0\ \ CQI_{avg}\ \ 0].$$

After the compression, the last two components of the transformed vector may be removed without loss of information, as the receiver knows in advance which elements of y' are zero and it uses that prior knowledge to decode CQI_5 and CQI_{avg} with no loss.

[0037] In an alternative, additional overhead reduction may be achieved by spreading the transmission of compressed metrics and averages over more than one transmission time interval (TTI). This alternative is illustrated in Figure 4. Suppose compression results in quality information being contained in P bits. Without spreading, P bits are transmitted in each TTI, 400. With spreading, the P bits are divided among K TTIs, 410, where K is greater than 1. The average bit overhead will then be P/K instead of P.

[0038] This embodiment may be extended for multi-layer, multi-code communication. In this scenario, quality metrics are reported for each layer for each sub-band. The quality metric values are contained in a matrix rather than a vector. The elements of the matrix may be the metric values themselves or difference values between each metric value and, for example, a maximum metric value. The information is then compressed by applying a two-dimensional compression transform, such a 2-D Haar transform. The result may be a matrix containing one relatively large element with the remaining elements having low values. This may then result in a significant reduction in feedback overhead when the compressed matrix is transmitted.

[0039] This embodiment may be applied to frequency partitioning. In this scenario, a transmission band is divided into sub-blocks. A quality metric is determined for each sub-block. The transmission band is divided into K partitions where K is at least 2. A first partition contains N1 best quality sub-blocks, a second partition contains the next best N2 sub-blocks which are not contained in the first partition, and so on through K partitions. For the first partition, the M1 sub-blocks out of N1with the best M1 quality metrics are selected and the previously described Haar best M1 embodiment is applied. For the second partition the best M2 sub-blocks are selected where M2 may not equal M1, and Haar best M2 embodiment is applied. In similar manner, Haar compression is applied to each of the K partitions. This technique reduces transmission overhead to

$$\left\lceil \log_2\binom{N_1-1}{M_1-1}+\log_2\binom{N_2-1}{M_2-1}+\cdots+\log_2\binom{N_K-1}{M_K-1}\right\rceil.$$

[0040] Similar partitioning may be employed in multiple input/multiple output (MIMO) communication schemes. For example, partitioning may be done over codewords, layers, or both.

[0041] Figure 3 illustrates an example of a third embodiment of a method for reducing feedback transmission overhead. In this embodiment, compression can be distributed over different time intervals. Communication resources, such as allocated frequencies and time intervals, are collected into resource blocks which are in turn organized into resource block groups (RBGs). A quality metric for each RBG is determined. The RBGs are divided into N groups. Locations of the groups are known in advance to both a WTRU and a BS. In a first reporting time interval (e.g. a transmission time interval TTI) a compression transform, such as a Haar best M transform as previously described, may be applied to the quality metrics in one of the groups and the compressed metrics transmitted. In

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each subsequent reporting time interval the compressed metrics for another of the N groups are reported until quality metrics for an entire frequency band are reported. In this embodiment overhead is reduced at least because the vector of metric values is reduced from N_{RBG} components to N_{RBG}/N.

[0042] Figure 3 illustrates a specific example of this embodiment in which N=2. A set of RBG's 300 is divided into N=2 groups, one containing even-numbered RBGs 310, the other containing odd-numbered RBGs 340. In reporting interval i, Haar best-M compression is applied to the even group 320 and the results are transmitted 330. In the next reporting interval i+1 Haar best-M compression is applied to the odd group 350 and the results are transmitted 360.

[0043] Table 1 shows a comparison of various overhead reduction schemes including some embodiments disclosed here, assuming each uncompressed quality metric is represented as five bits. In particular, percentage reduction in overhead for Haar Best-M Individual is shown as compared to Best-M individual without Haar compression.

Scheme	Signalling Cost (bits)	N_{sb}=25		
		M=4	M=5	M=7
Full Feedback	$5 \times N_{sb}$	125 bits	125 bits	125 bits
Best-M Average	$5 + \left\lceil \log_2 \binom{N_{sb}}{M} \right\rceil + 5$	24 bits	26 bits	29 bits
Best-M Individual	$5 \times M + \left\lceil \log_2 \binom{N_{sb}}{M} \right\rceil + 5$	39 bits	46 bits	59 bits
Haar Best-M Individual	$N_{Haar} + \left\lceil \log_2 \binom{N_{sb}}{M} \right\rceil$	29 bits (~ %25)	34 bits (~ %25)	40 bits (~ %32)
Best-M DM	$2 \times M + 5 + \left\lceil \log_2 \binom{N_{sb}}{M} \right\rceil + 5$	32 bits	36 bits	43 bits
DCT Significant-M	$5 \times M + \left\lceil \log_2 \binom{N_{sb}-1}{M-1} \right\rceil$	31 bits	39 bits	53 bits
DCT Partitioning	$5 \times (N_1 + N_2) + \left\lceil \log_2 \binom{N_{sb}}{M} + \log_2 \binom{M-1}{N_1-1} + \log_2 \binom{N_{sb}-M-1}{N_2-1} \right\rceil$	N_1=3, N_2=1 34 bits	N_1=4, N_2=1 43 bits	N_1=6, N_2=1 57 bits

Table 1 Overhead comparison of CQI compression schemes

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[0044] The embodiments described herein may be implemented, for example, in a wireless transmit/receive unit (WTRU) such as shown in Figure 5. The WTRU may use the method to transmit channel quality information to a base station, which in turn may use the information to select the best quality channels to use for communicating with the WTRU. WTRU 500 may contain a receiver 510 , a transmitter 515, and a processor 520. Receiver 510 may receive signals over various channels. Processor 520 may use the received information to determine quality metrics, organize the metrics into groups, average the metrics and compress the metrics. Transmitter 515 may transmit the averaged and/or compressed metrics with overhead reduced using the disclosed method.

[0045] Embodiments:

1. A method for compressing quality metrics transmitted in wireless communications using a plurality of sub-bands, comprising:

selecting the M best quality metrics for each sub-band;

measuring an average of the quality metrics of the remaining sub-bands;

creating a vector containing the M best quality metrics and the average; and

performing a compression transform on the vector to produce a transformed vector.

2. The method of embodiment 1 further comprising eliminating the last element of the transformed vector prior to transmission.

3. The method of embodiment 2 further comprising quantizing the remaining elements of the transformed vector.

4. A method as in embodiments 1, 2 or 3 wherein values of the M best quality metrics are reported in the vector in the same order as the relevant sub-band.

5. A method as in any preceding embodiment further comprising transmitting the transformed vector.

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6. A user equipment in a wireless communications network transmitting the compressed quality metrics using the method as in embodiments 1, 2, 3 or 4.

7. A base station in a wireless communications network receiving from the user equipment as in embodiment 6 the compressed quality metrics.

8. A method as in any of embodiments 1, 3 or 5 further comprising re-arranging the Best M vector values by dispersing any zero values before performing the compression transform.

9. The method of embodiment 8 further comprising eliminating two elements from the transformed vector for transmission.

10. A method as in embodiments 8 or 9 further comprising transmitting the compressed quality metrics.

11. A user equipment in a wireless communications network transmitting a quality metric as compressed using the method as in any of embodiments 8 - 10.

12. A base station in a wireless communications network receiving from the user equipment as in embodiment 11 the compressed quality metric.

13. A method as in any of embodiments 1-5, or 9-10, wherein in a multi-code/multi-layer system, the value of quality metrics of each layer are compressed and reported.

14. The method of embodiment 13 further comprising reporting the values of the quality metrics for each layer per sub-band.

15. The method of embodiment 13 or 14 further comprising:

reporting the metric having the highest value;

determining the difference between the highest value and the metric values for each of the remaining layers; and

reporting the difference for each of the remaining layers.

16. A method for compressing a channel quality metric comprising:

partitioning a transmission band into two or more partitions;

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selecting the M1 best metrics for each sub-band in a first partition;

measuring the average of the remaining sub-bands in the first partition;

creating a first vector; and

performing a compression transform on the first vector to produce a first transformed vector.

17. The method of embodiment 16, wherein the first partition comprises strongest N1 sub-blocks in a plurality of sub-blocks.

18. The method of embodiments 16 or 17 further comprising:

selecting the M2 best metrics for each sub-band in a second partition;

measuring the average of the remaining sub-bands in the second partition;

creating a second vector; and

performing a compression transform on the second vector to produce a second transformed vector.

19. The method of embodiment 18, wherein the second partition comprises the next strongest N2 blocks that are not included in the first partition.

20. A method as in any of embodiments 16 - 19 further comprising eliminating the last element of the transformed vectors.

21. A method of embodiments 20 further comprising quantizing the remaining elements of the transformed vectors.

22. A method as in any of embodiments 17-19, further comprising eliminating two elements from the transformed vectors for transmission.

23. A method as in any preceding embodiment further comprising transmitting the transformed vectors.

24. A user equipment in a wireless communications network transmitting metrics compressed using the method of any one of embodiments 1-5, 8-10, and 13-23.

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25. A base station in a wireless communications network receiving from the user equipment as in embodiment 24 the compressed metrics.

26. A method of reporting a channel quality metric in wireless communications, the method comprising:

selecting M strongest frequency bands based on signal strength;

classifying the M bands into Q groups based on signal strength;

determining Q averaged primary quality metric values for the Q groups of M bands; and

determining an averaged secondary quality metric for all other bands.

27. The method of embodiment 26 wherein a first group of Q groups contains the strongest bands and a second group of Q groups contains the second strongest band.

28. A method as in any one of all preceding embodiments further comprising a first wireless device transmitting a first location index referencing a first communication band to a second wireless device.

29. The method as in embodiment 28 wherein the first communication band has the strongest quality metric value.

30. The method as in embodiment 28 or 29 further comprising the first wireless device transmitting a second location index referencing a second location band to the second wireless device.

31. The method as in embodiment 30 wherein the second location band has the second strongest quality metric value.

32. A method as in any preceding embodiment, wherein the value Q is selected such that no more than one of Q groups contains a single band.

33. A method as in any preceding embodiment, wherein $1 < Q < M$.

34. The method as in any one of embodiments 31-33 further comprising the first wireless device transmitting a location index referencing

each of the communication bands for which a primary average value has been determined to the second wireless device.

35. The method as in any one of embodiments 31-34 further comprising the first wireless device transmitting a plurality of averages of groups of quality metrics to the second wireless device.

36. The method as in embodiment 35 further comprising determining an average of each of a plurality of groups with the strongest quality metrics.

37. The method as in embodiment 36 further comprising determining an average of a remaining group wherein the remaining group is not a member of the plurality of groups with the strongest quality metrics.

38. The method as in embodiment 36 or 37 further comprising a first wireless device transmitting to a second wireless device the average of each of the plurality of groups with the strongest quality metrics.

39. The method as in embodiment 37 or 38 further comprising the first wireless device transmitting to a second wireless device the average of the remaining groups.

40. The method as in any one of embodiments 31-39 further comprising the first wireless device transmitting to the second wireless device an average of a first group, wherein the first group has the strongest quality metrics.

41. The method as embodiment 40 further comprising the first wireless device transmitting to the second wireless device a delta quality metric value referenced to the average of the first group.

42. A method as in any preceding embodiment, further comprising transmitting from a first wireless device a label indicating the location of M strongest bands.

43. A method as in any preceding embodiment, further comprising transmitting a label showing ceil(M/2) bands belonging to the first group of Q groups.

44. The method as in any one of embodiments 31-41 wherein the first wireless device is a WTRU.

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45. The method as in any one of embodiments 31-42 wherein the second wireless device is a Node-B.

46. A method as in any preceding embodiment, further comprising compressing quality metrics and spread bits.

47. A method as in any preceding embodiment, further comprising dividing resource block groups (RBGs) into N groups.

48. A method as in any preceding embodiment wherein locations of groups are known to a wireless transmit/receive unit (WTRU) and/or Node B (NB).

49. A method as in any preceding embodiment, further comprising uniformly spreading RBGs across a band.

50. A method as in any preceding embodiment, further comprising applying a compression transform at each of a plurality of reporting intervals.

51. A method as in any preceding embodiment, further comprising dividing RGB's to odd and even groups.

52. A method as in embodiment 51, further comprising applying compression of Best-M to either an even or an odd group.

53. A method as in any preceding embodiment, further comprising extending an update interval of feedback to a number K of transmission time intervals (TTIs).

54. A method as in any preceding embodiment wherein an average number of quality metric bits is reduced by spreading over several TTIs.

55. A method as in any preceding embodiment wherein an average bit overhead is P/K, where P bits result from a compression.

56. The method of any preceding embodiment wherein the quality metric is a channel quality indication (CQI).

57. The method of any preceding embodiment wherein the compression transform is a Haar transform.

58. A WTRU configured to perform the method as in any preceding embodiment.

59. A base station configured to perform the method as in any preceding embodiment.

60. An integrated circuit configured to perform the method as in any preceding embodiment.

[0046] Although features and elements are described above in particular combinations, each feature or element can be used alone without the other features and elements or in various combinations with or without other features and elements. The methods or flow charts provided herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

[0047] Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

[0048] A processor in association with software may be used to implement a radio frequency transceiver for use in a wireless transmit receive unit (WTRU), user equipment (UE), terminal, base station, radio network controller (RNC), or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) or Ultra Wide Band (UWB) module.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A wireless transmit/receive unit (WTRU) including:

a processor configured to determine a channel quality index (CQI) for a first transmission layer of each of N groups of frequency resource blocks;

wherein the N groups of frequency resource blocks divide a downlink bandwidth;

wherein the processor is configured to transmit each of the N channel quality indices in a different reporting transmission time interval (TTI); and

wherein the processor is further configured to transmit, along with each of the N channel quality indices, a channel quality index corresponding to at least a second transmission layer for the corresponding frequency resource blocks.

2. The WTRU of claim 1 wherein the reporting transmission time interval and the frequency resource block group to be reported in that reporting transmission time interval are known in advance of the transmission by the WTRU and a wireless network.

3. The WTRU of claim 1 wherein the transmission in each of the reporting transmission time intervals does not include an index of a position of the group within the downlink bandwidth.

4. A method including:

determining, by a wireless transmit/receive unit (WTRU), a channel quality index (CQI) for a first transmission layer of each of N groups of frequency resource blocks, wherein the N groups of frequency resource blocks divide a downlink bandwidth;

transmitting, by the WTRU, each of the N channel quality indices in different reporting transmission time intervals; and

transmitting, along with each of the N channel quality indices, information indicating a channel quality index corresponding to at least a second layer for the corresponding frequency resource blocks.

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5. The method of claim 4 wherein the reporting transmission time interval and the frequency resource block group to be reported in that reporting transmission time interval are known in advance of the transmission by the WTRU and a wireless network.

6. The method of claim 4 wherein the transmission in each of the reporting transmission time intervals does not include an index of a position of the group within the downlink bandwidth.

7. A wireless network node including:

a processor and a receiver configured to receive channel quality index (CQI) information from one wireless transmit/receive unit (WTRU) in N reporting transmission time intervals (TTIs);

wherein the CQI information in each of the N reporting TTIs corresponds to a first transmission layer of a respective one of N groups of frequency resource blocks;

wherein the N groups of frequency resource blocks divide a downlink bandwidth; and

wherein the processor is configured to receive, in each of the N TTIs, information indicating a channel quality index corresponding to at least a second layer for the corresponding frequency resource blocks.

8. The wireless network device of claim 7 wherein each reporting transmission time interval and the frequency resource block group to be reported in that reporting transmission time interval are known in advance of reception by the wireless network device.

9. The wireless network device of claim 7 wherein information received in the N reporting TTIs does not include an index of a position of the group within the downlink bandwidth.

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10. The wireless network device of claim 7 wherein the processor is further configured to determine a CQI for all of the N groups from CQI information in each of the N reporting TTIs.

11. The WTRU of claim 1 and substantially as hereinbefore described with reference to the accompanying figures.

12. The method of claim 4 and substantially as hereinbefore described with reference to the accompanying figures.

13. The wireless network device of claim 7 and substantially as hereinbefore described with reference to the accompanying figures.

INTERDIGITAL TECHNOLOGY CORPORATION

WATERMARK PATENT & TRADE MARK ATTORNEYS

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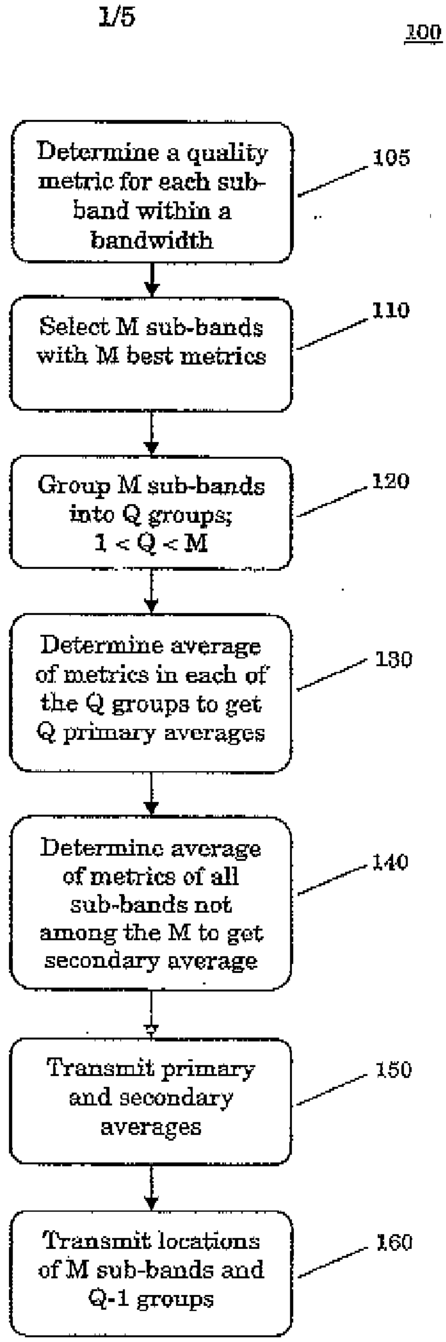

Fig. 1

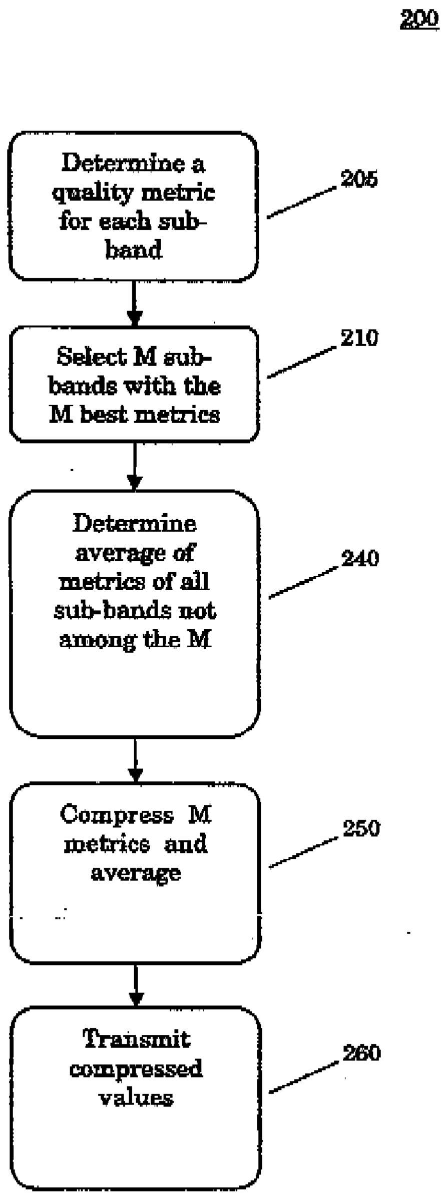
200
Determine a quality metric for each sub-band
205
Select M sub-bands with the M best metrics
210
Determine average of metrics of all sub-bands not among the M
240
Compress M metrics and average
250
Transmit compressed values
260

Fig. 2

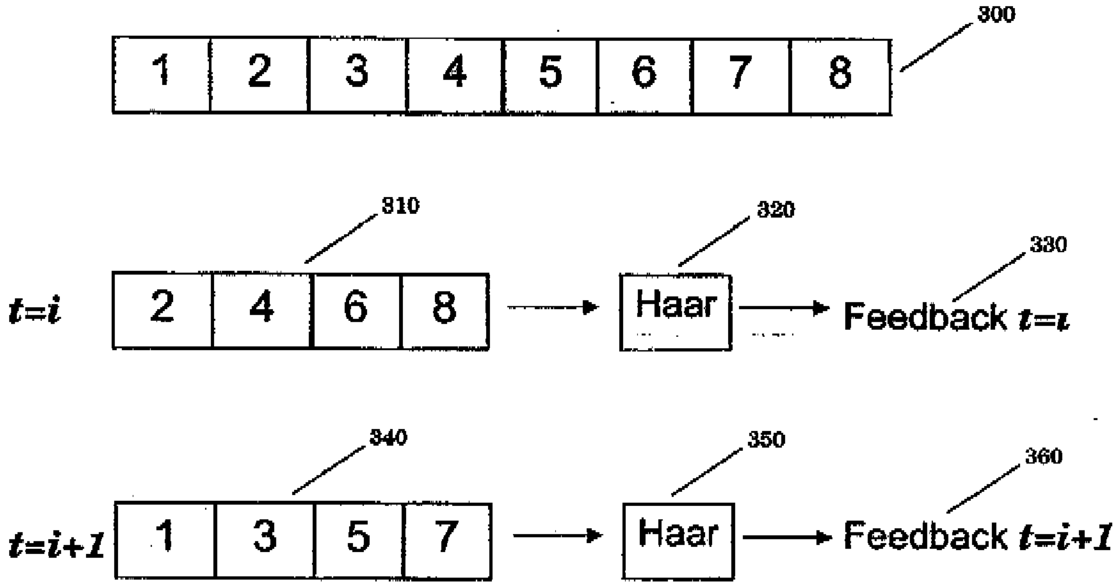
300
1
2
3
4
5
6
7
8
810
320
330
t=i
2
4
6
8
Haar
Feedback t=i
340
350
360
t=i+1
1
3
5
7
Haar
Feedback t=i+1

Fig. 3

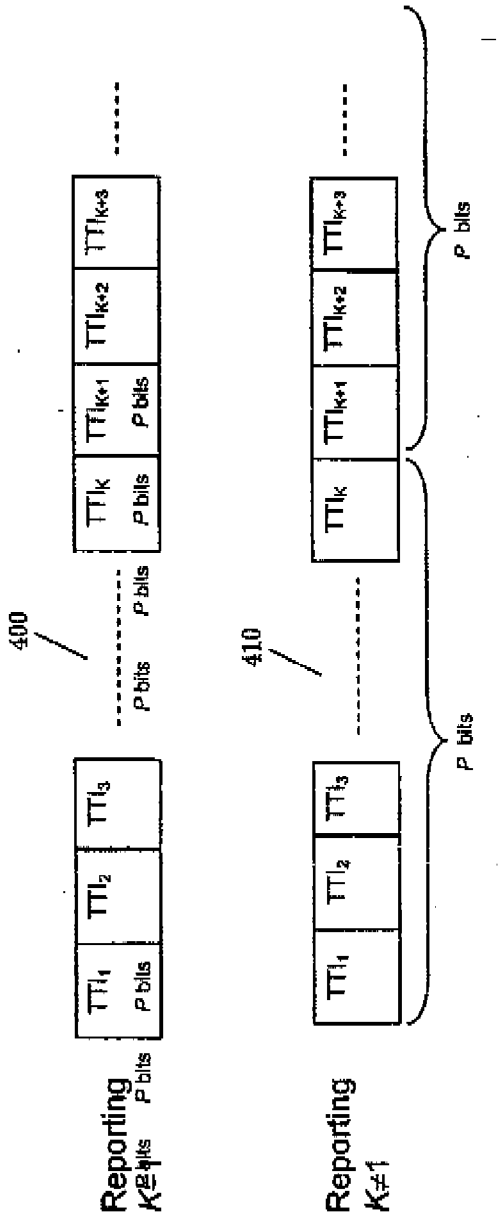
400
410
Reporting K=1
Reporting K≠1
TTI1
TTI2
TTI3
TTIk
TTIk+1
TTIk+2
TTIk+3
P bits

Fig. 4

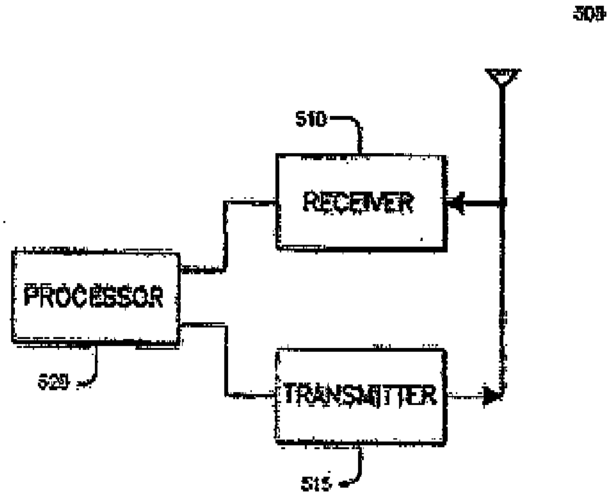

Fig. 5