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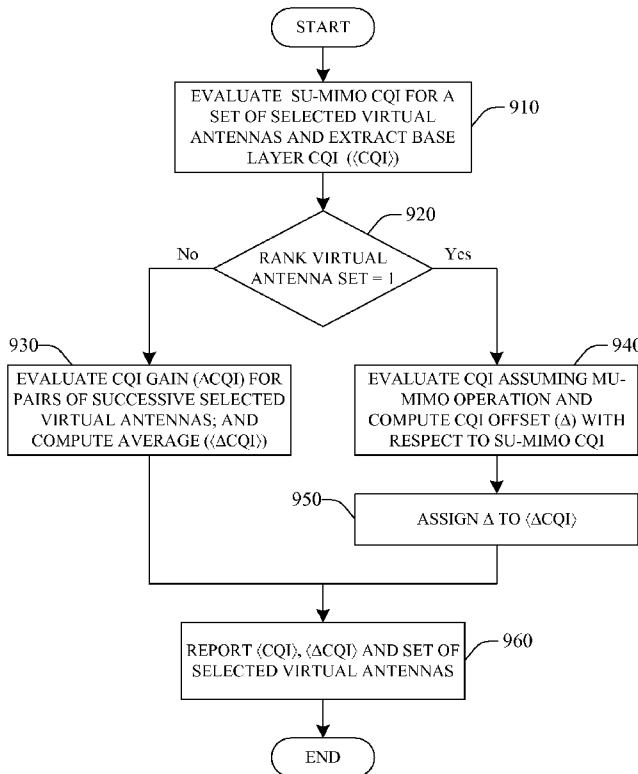
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[Continued on next page]

(54) Title: APPROACH TO A UNIFIED SU-MIMO/MU-MIMO OPERATION



(57) Abstract: What is disclosed is an apparatus and method to dynamically schedule user devices in a wireless communication system in single-user multiple-input multiple-output (SU-MIMO) or multiple-user multiple-input multiple-output (MU-MIMO) modes of operation. The dynamic scheduling employs an efficient differential reporting of channel state information that reduces uplink feedback overhead, whereby a base layer value of a channel quality indicator (CQI) is reported in conjunction with a CQI offset value. Antenna subset selection is also reported. The offset value reflects gains by detection with successive interference cancellation if multiple antennas are reported (rank > 1), while it reflects the actual offset between single-layer SU-MIMO CQI and MU-MIMO CQI if a single antenna is reported (rank = 1). Scheduled SU-MIMO mode of operation is optimized for a user reporting either a single antenna or multiple antennas, whereas MU-MIMO operation is optimized for a user reporting a single antenna, in terms of accuracy of data rate and constellation size restorable at a transmitter based on the reported channel quality indicator.

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Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
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- *with international search report (Art. 21(3))*

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/076420

A. CLASSIFICATION OF SUBJECT MATTER INV. H04B7/06		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) H04B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	QUALCOMM EUROPE: "Description and link simulations of MIMO schemes for OFDMA based E-UTRA downlink evaluation" 3GPP DRAFT; R1-050903, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. London, UK; 20050825, 25 August 2005 (2005-08-25), XP050100523 page 6 - page 9	1-3, 10, 12, 16-20
<input type="checkbox"/> Further documents are listed in the continuation of Box C.		
<input type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
"E" earlier document but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.	
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 15 March 2010	Date of mailing of the international search report 12/05/2010	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Franz, Volker	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/076420

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

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

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

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

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

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

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

see additional sheet

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-3, 10, 12, 16-20

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-3, 10, 12, 16-20

An apparatus comprising a processor configured to evaluate CQI and delta CQI, select antennas, send reports, detect data employing successive interference cancellation, wherein the CQI corresponds to at least one of signal-to-noise-and-interference ration, throughput and peak data rate.

1.1. claims: 10, 17-18

The processor quantises the CQI value to a number of bits and quantises the delta CQIs to a smaller number of bits.

2. claims: 4, 13-15

The processor evaluates channel quality indicator base layer value by assuming single-user MIMO operation mode.

3. claim: 5

The processor evaluates the CQI base layer value as the average CQI over a set of multiple virtual antennas.

4. claim: 6

The processor evaluates the CQI base layer value by assuming that data layers are symmetrically permuted in frequency-domain or time-domain before being transmitted using cyclic or pseudo-random permutation.

5. claim: 7

The processor computes successive interference cancellation gain between successively decoded data layers when multiple virtual antennas are selected.

6. claim: 8

The processor evaluates the delta CQI by computing the average of successive interference cancellation gains over multiple virtual antennas.

7. claim: 9

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

The processor of e.g. a terminal that evaluates the CQI offset value by computing the difference between single-user MIMO and multi-user MIMO when a single virtual antenna is selected.

8. claim: 11

The processor selects a virtual antenna set by computing a channel quality indicator over a plurality of virtual antenna configurations.

9. claims: 21-34

An apparatus comprising a processor comprising a scheduler that dynamically determines a user device operates in single-user MIMO or multi-user MIMO mode.
