

[54] **ADAPTIVE BEAM FORMING FOR TRANSMITTER OPERATION IN A WIRELESS COMMUNICATION SYSTEM**

[75] Inventors: **Gregory Gene Raleigh**, El Granada; **Suhans Nagraj Diggavi**, Stanford; **Vincent Knowles Jones, IV**, Redwood Shores; **Arogyaswami Joseph Paulraj**, Stanford, all of Calif.

[73] Assignees: **The Board of Trustees of the Leland Stanford Jr. University**, Stanford; **Cisco Technology, Inc.**, San Jose, both of Calif.

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/491,044**

[22] Filed: **Jun. 16, 1995**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/394,652, Feb. 22, 1995.

[51] **Int. Cl.⁷** **H04Q 7/30**

[52] **U.S. Cl.** **455/561; 455/456; 455/65; 455/276.1; 342/367; 375/232**

[58] **Field of Search** **455/33.1, 54.2, 455/54.1, 56.1, 63, 65, 67.1, 4, 115, 52.3, 226.1, 276.1, 272, 422, 440, 441, 456, 457, 517, 524, 525, 561, 562; 379/58, 59; 342/350, 367, 368, 372, 373, 378; 395/51; 375/316, 347, 349, 231, 230, 232**

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,132,694	7/1992	Sveenivas	342/373
5,260,968	11/1993	Gardner et al.	375/1
5,274,844	12/1993	Harrison et al.	455/25
5,386,589	1/1995	Kanai	455/69 X

5,412,414	5/1995	Ast et al.	342/372 X
5,428,712	6/1995	Elad et al.	395/51
5,495,256	2/1996	Piper	342/378 X
5,515,378	5/1996	Roy, III et al.	455/525
5,542,101	7/1996	Pal	455/276.1 X

FOREIGN PATENT DOCUMENTS

0142293 A3	10/1984	European Pat. Off.	G01S 7/28
0595247 A1	10/1993	European Pat. Off.	H01Q 3/26
2266998A	11/1993	United Kingdom	H01Q 3/26
WO 94/09568	4/1994	WIPO	H04B 1/10
WO9534997	12/1995	WIPO	

OTHER PUBLICATIONS

Per Zetterberg, The Spectrum Efficiency of a Basestation Antenna Array System For Spatially Selective Transmission, Jan. 24, 1994, pp. 1-37.

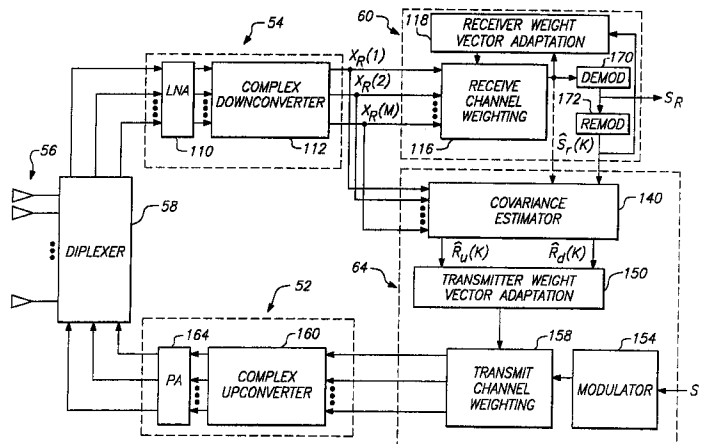
Per Zetterberg, Björn Ott4ersten, Experiments using an Antenna Array in a Mobile Communications Environment, Apr. 21, 1994, 5 pages.

Primary Examiner—Fan Tsang
Assistant Examiner—Philip J. Sobutka
Attorney, Agent, or Firm—Ritter Van Pelt & Yi LLP

[57] **ABSTRACT**

A method for forming an adaptive phased array transmission beam pattern at a base station without any knowledge of array geometry or mobile feedback is described. The approach is immune to the problems which plague methods which attempt to identify received angles of arrival from the mobile and map this information to an optimum transmit beam pattern. In addition, this approach does not suffer the capacity penalty and mobile handset complexity increase associated with mobile feedback. Estimates of the receive vector propagation channels are used to estimate transmit vector channel covariance matrices which form objectives and constraints in quadratic optimization problems leading to optimum beam former solutions for the single user case, and multiple user case. The new invention is capable of substantial frequency re-use capacity improvement in a multiple user cellular network.

13 Claims, 11 Drawing Sheets



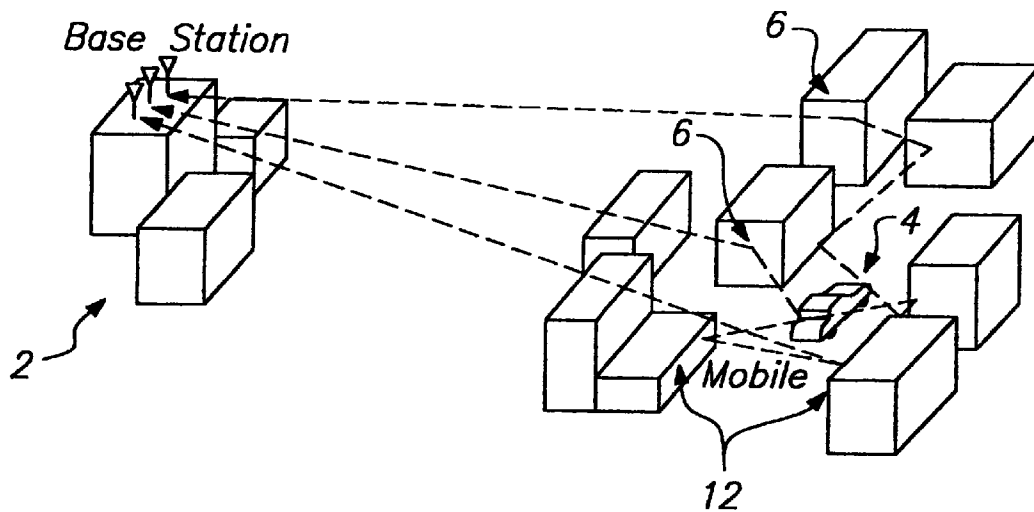


FIG. 1

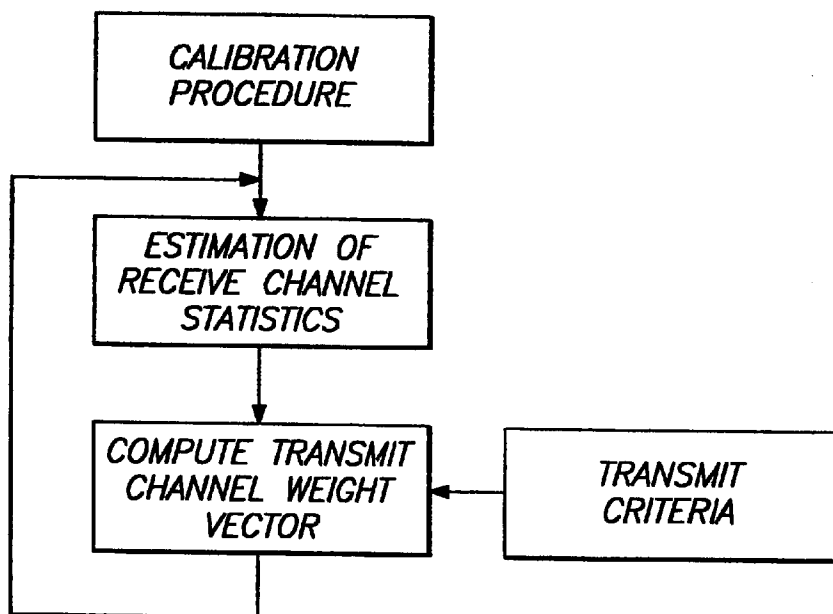


FIG. 4

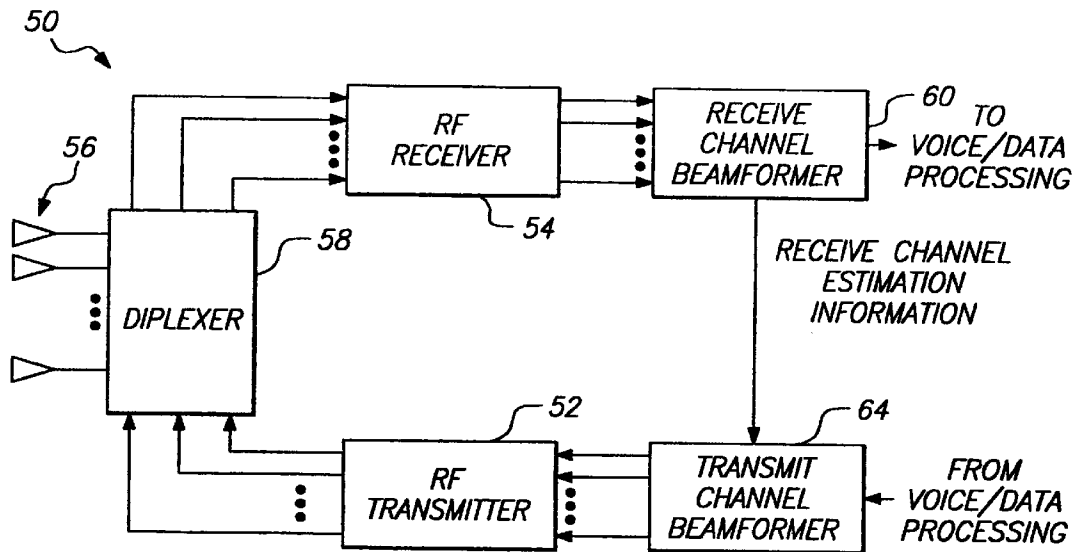


FIG. 2A

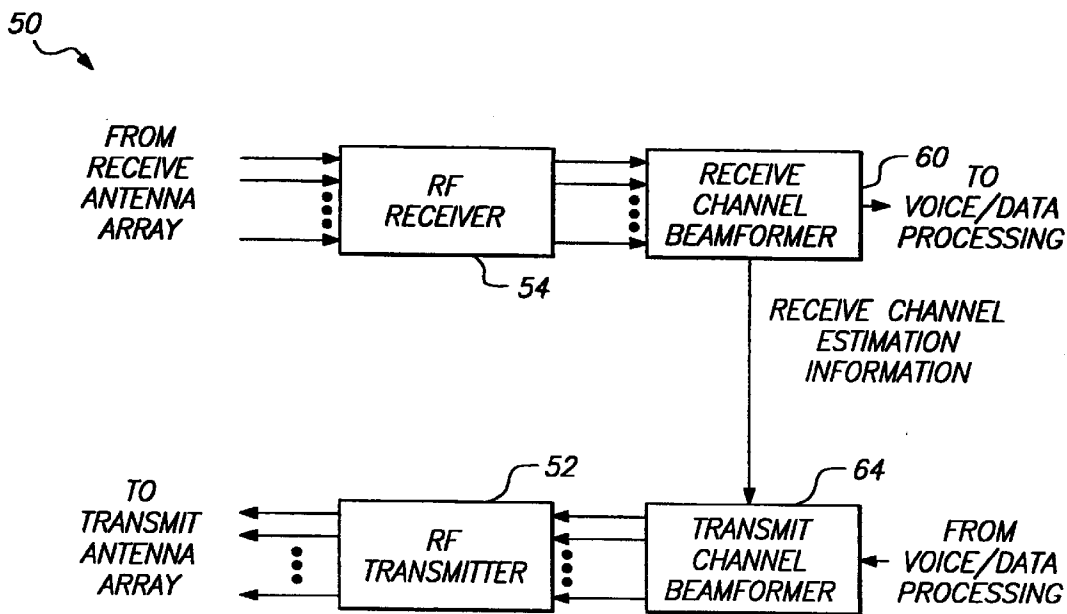


FIG. 2B

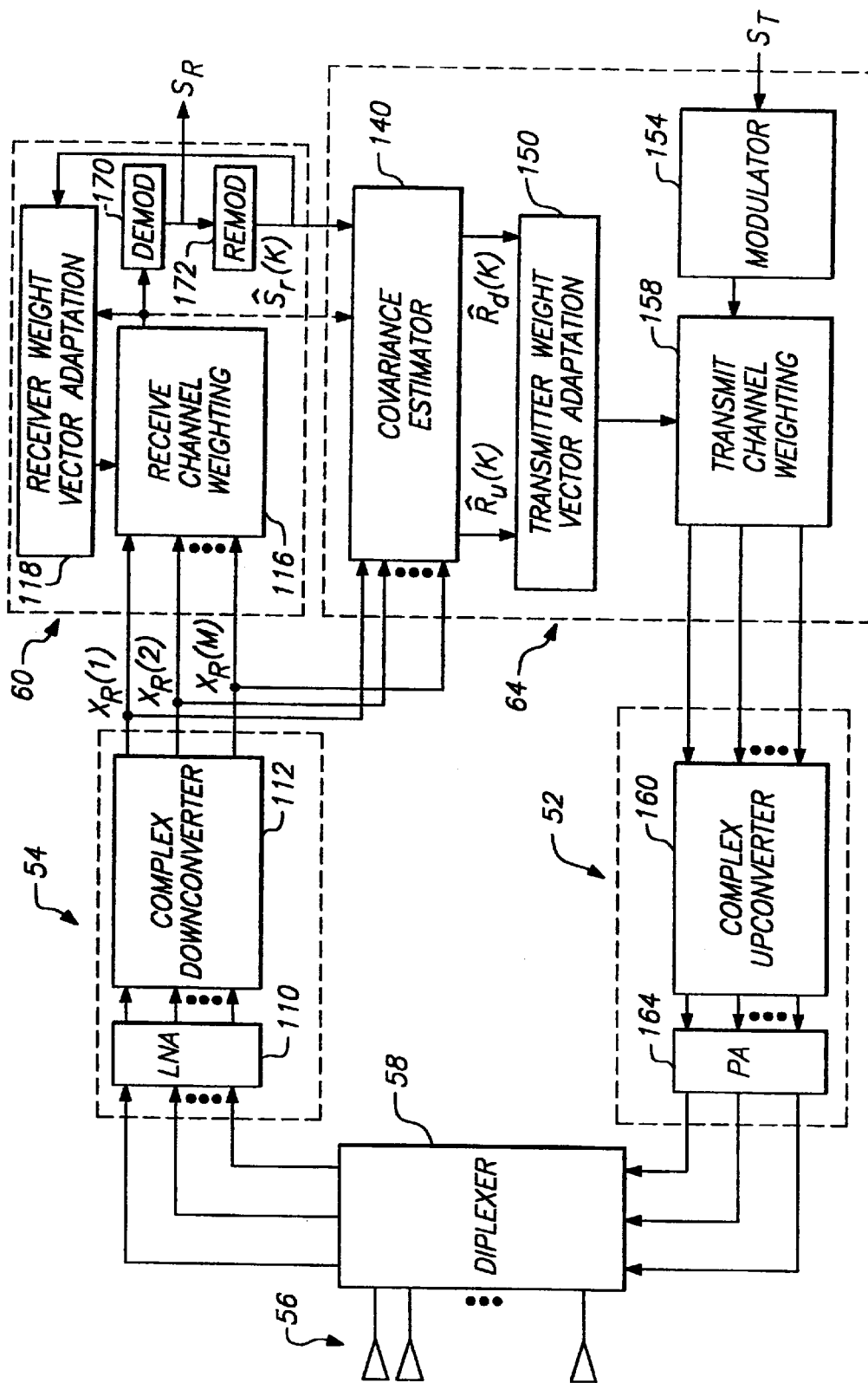


FIG. 3

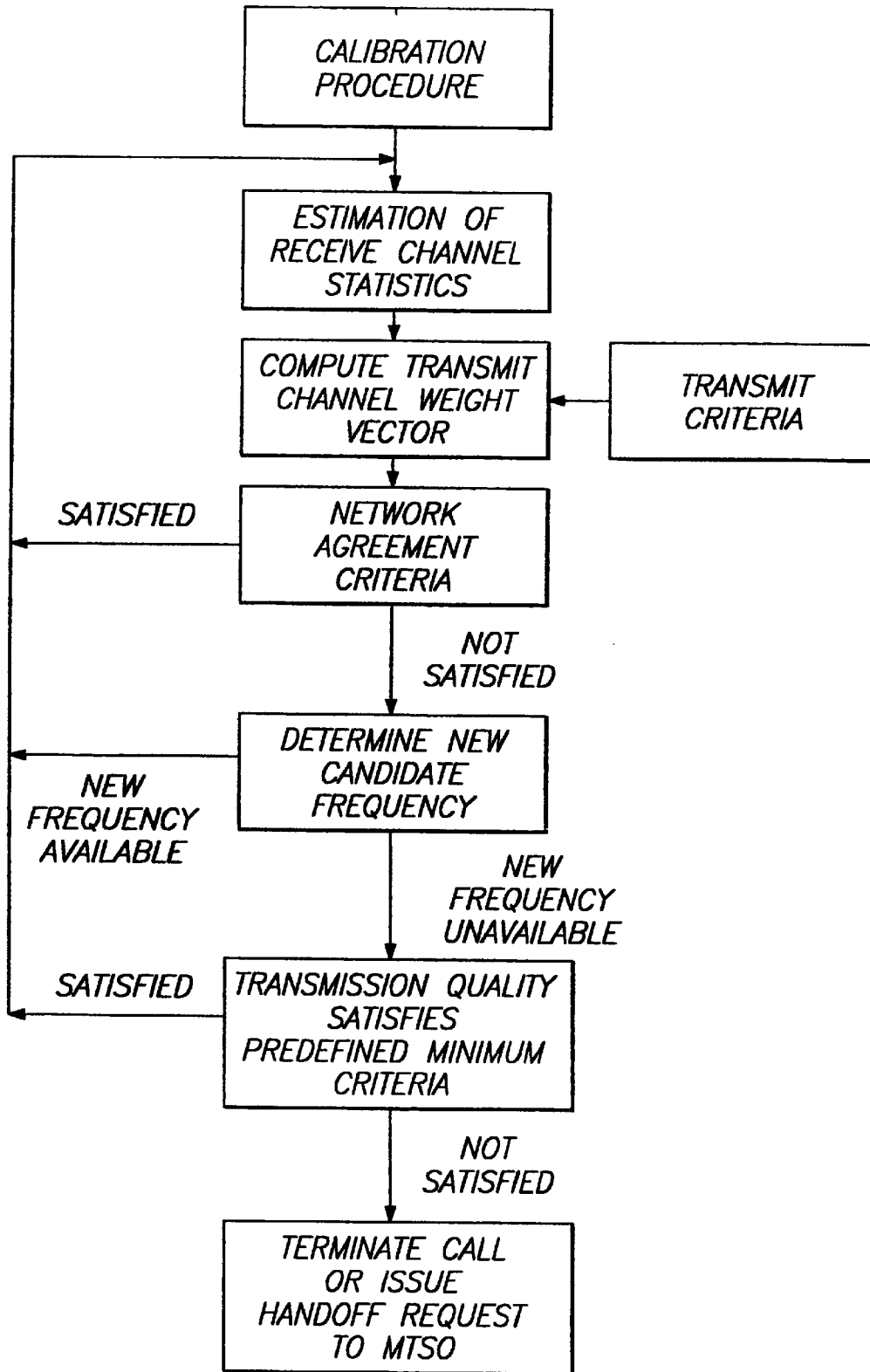


FIG. 5

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.