



(12) **United States Patent**
Mao et al.

(10) **Patent No.:** **US 7,312,750 B2**
(45) **Date of Patent:** **Dec. 25, 2007**

(54) **ADAPTIVE BEAM-FORMING SYSTEM
USING HIERARCHICAL WEIGHT BANKS
FOR ANTENNA ARRAY IN WIRELESS
COMMUNICATION SYSTEM**

7,088,288 B1 * 8/2006 Margolese et al. 342/377
7,099,383 B2 * 8/2006 Struhsaker et al. 375/222
2003/0222818 A1 12/2003 Regnier et al.
2005/0143132 A1 * 6/2005 Proctor et al. 455/561

(75) Inventors: **Jian Mao**, Gaithersburg, MD (US);
Oscar Frederick Somerlok, III,
Potomac, MD (US)

FOREIGN PATENT DOCUMENTS

EP 1394966 A2 3/2004

(73) Assignee: **Comware, Inc.**, Rockville, MD (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 300 days.

OTHER PUBLICATIONS

Godara, L., "Application of Antenna Arrays to Mobile Communi-
cations, Part II: Beam-Forming and Direction-of-Arrival Consider-
ations," *Proceedings of the IEEE*, vol. 85, No. 8, Aug. 1997, pp.
1195-1245.

Van Veen et al., "Beamforming: A Versatile Approach to Spatial
Filtering," *IEEE ASSP Magazine*, Apr. 1988, pp. 4-24.

* cited by examiner

Primary Examiner—Dao Phan

(74) *Attorney, Agent, or Firm*—Pillsbury Winthrop Shaw
Pittman, LLP

(65) **Prior Publication Data**

US 2005/0206564 A1 Sep. 22, 2005

Related U.S. Application Data

(60) Provisional application No. 60/554,408, filed on Mar.
19, 2004.

(51) **Int. Cl.**
H01Q 3/22 (2006.01)
H01Q 3/26 (2006.01)

(52) **U.S. Cl.** **342/377; 342/373**

(58) **Field of Classification Search** **342/367,**
342/373, 377, 378, 383; 455/69, 101, 562.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,049,307 A 4/2000 Lim

(57) **ABSTRACT**

An adaptive beam-forming system using hierarchical weight banks for antenna arrays in wireless communication systems is disclosed. The present invention can be applied for both reception and transmission beam-forming. The hierarchical weight banks contain weights that are pre-calculated based on pre-set beam look directions. By comparing measurements of chosen signal quality metrics for pre-set look directions, the best weights, and thus the best beam look direction, can be selected from the weight banks.

41 Claims, 10 Drawing Sheets

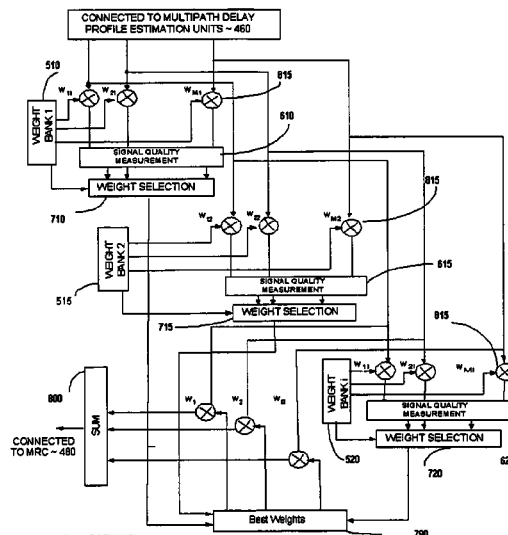


FIG. 1

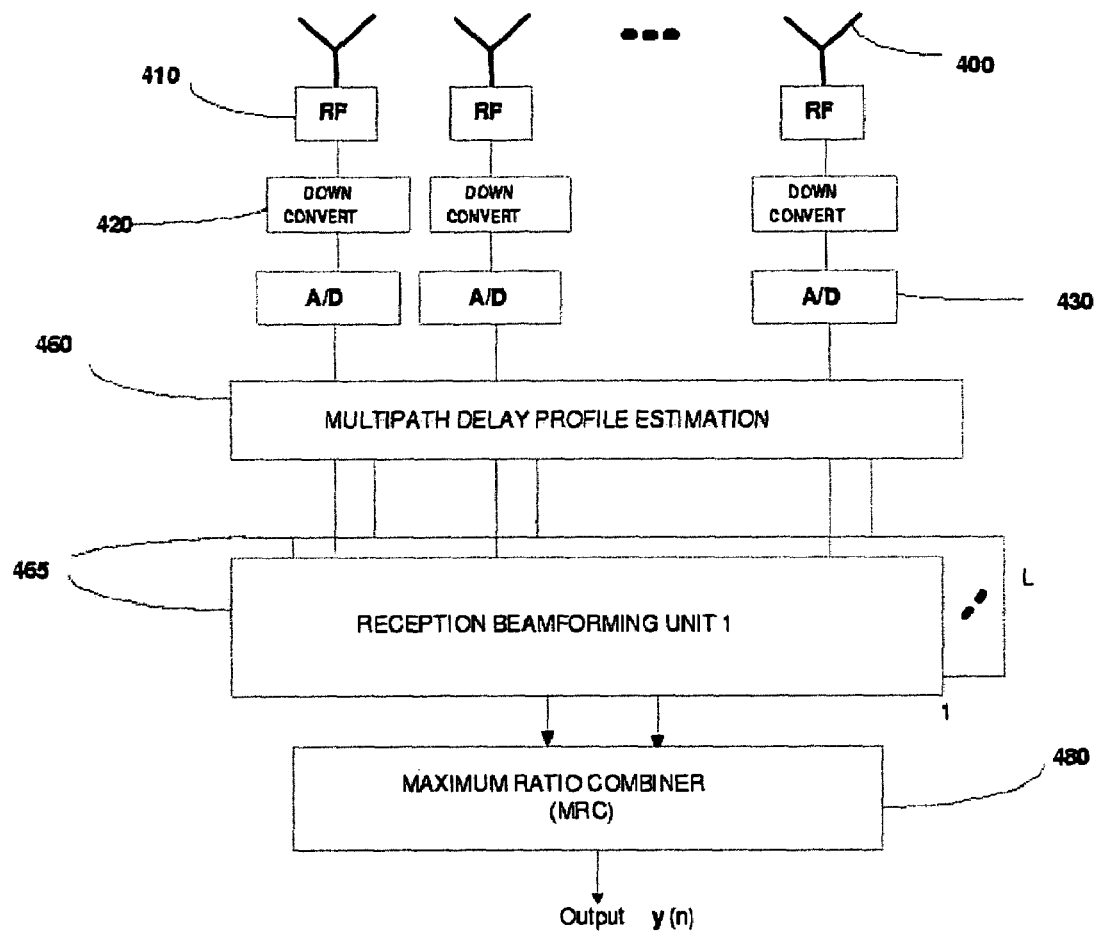


FIG. 2

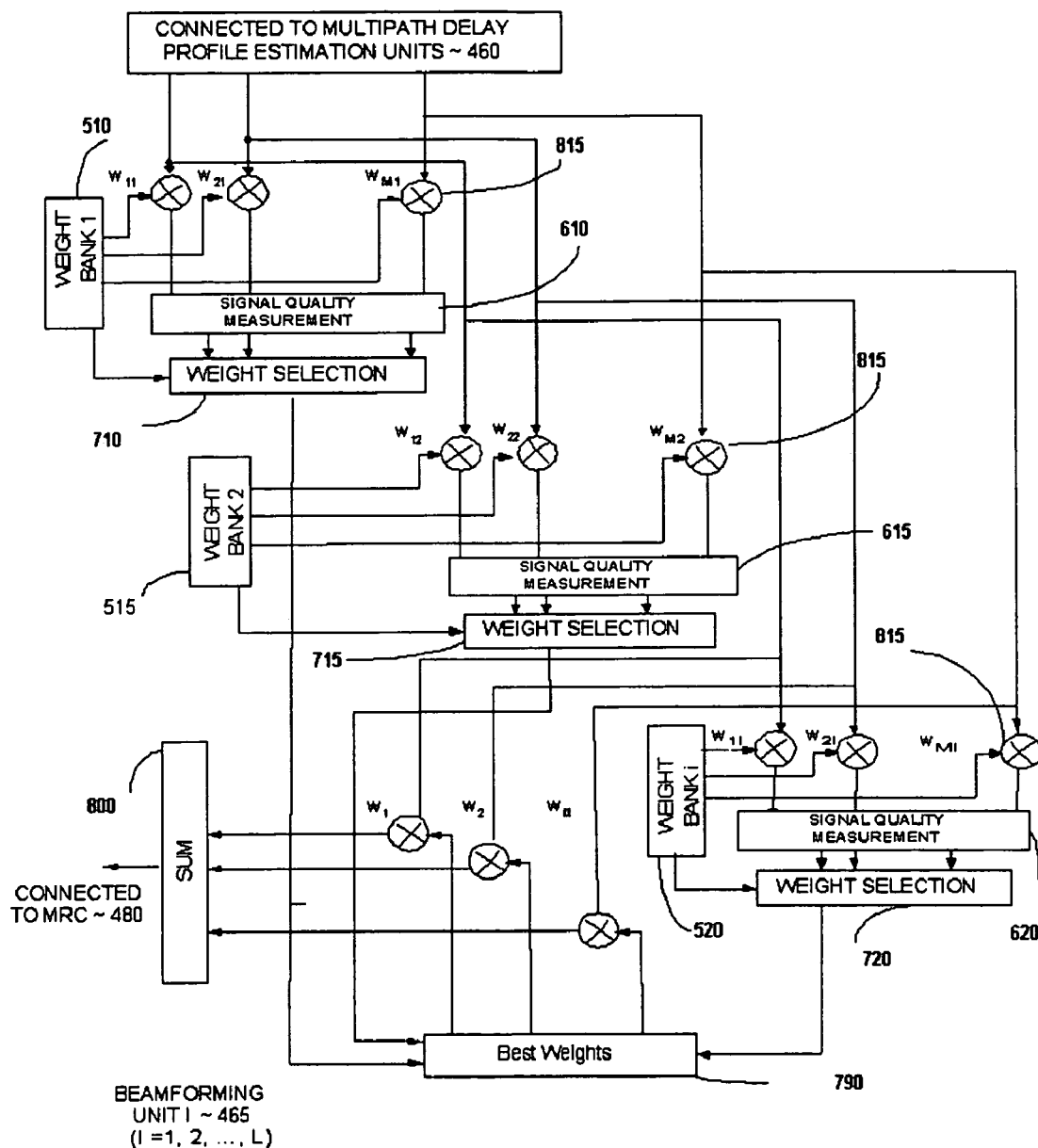


FIG. 3

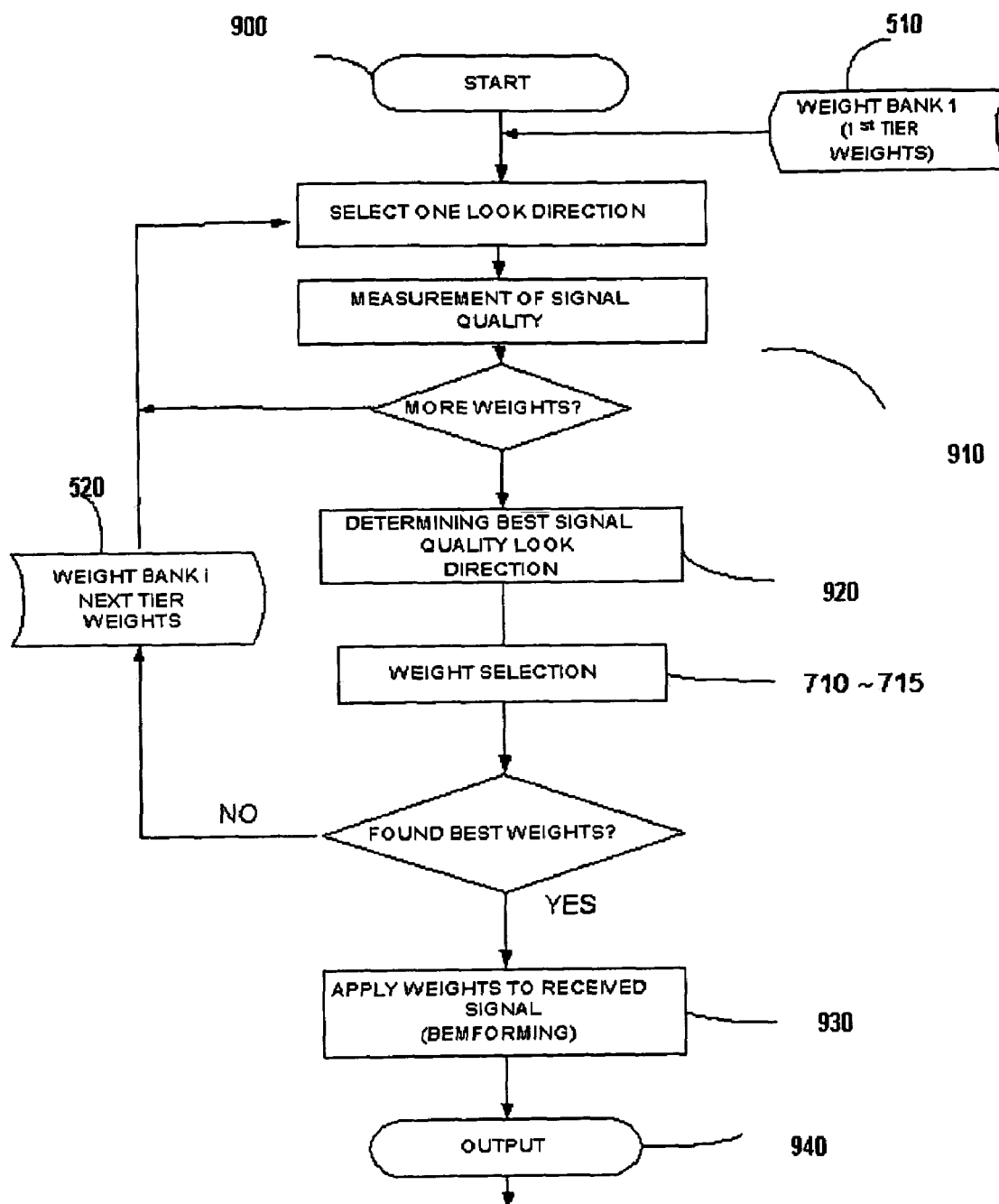
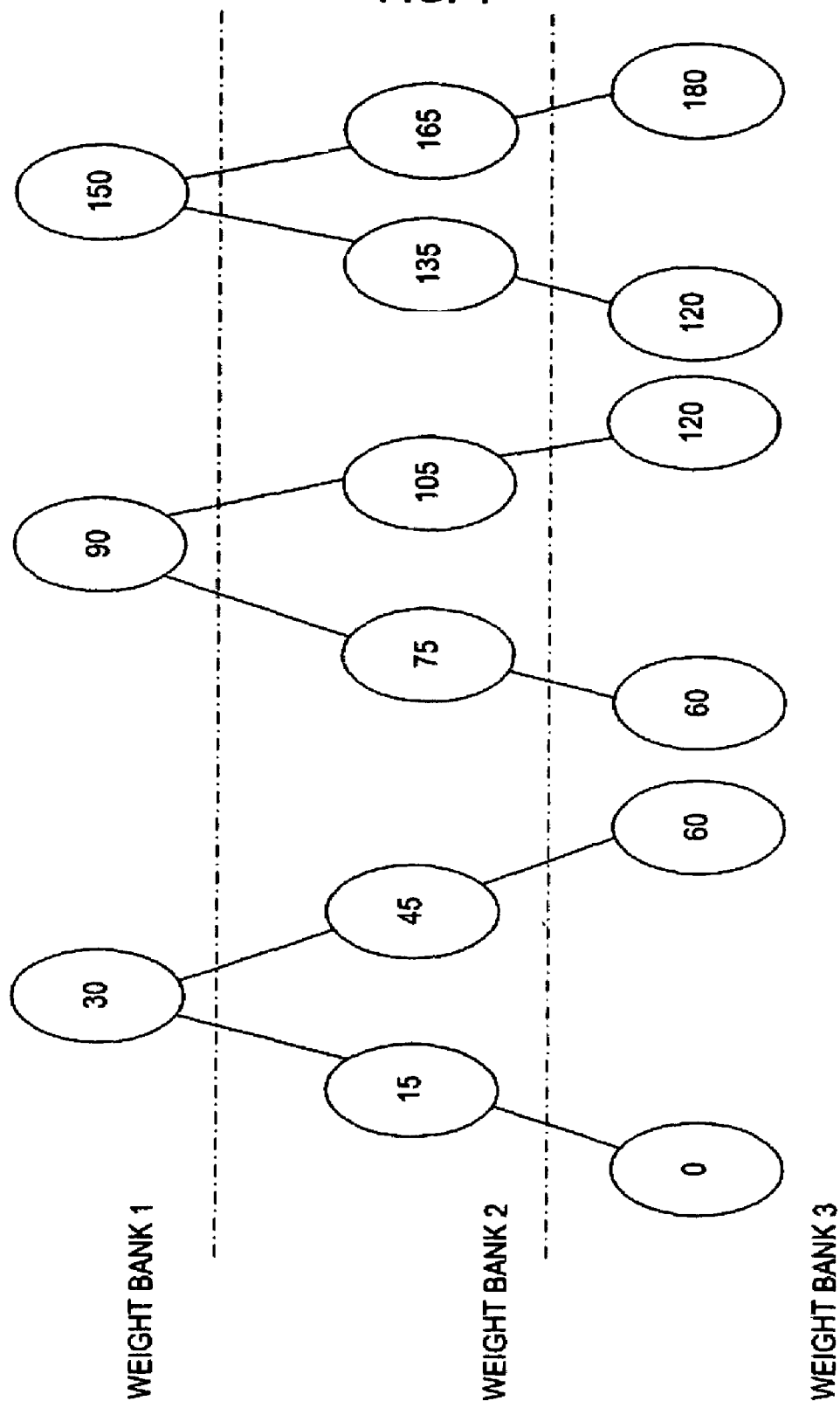


FIG. 4



The beam direction search resolution = 15°



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.