



US007408976B1

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

(10) **Patent No.:** **US 7,408,976 B1**
(45) **Date of Patent:** **Aug. 5, 2008**

(54) **MIMO-OFDM RECEIVER PROCESSING WITH FREQUENCY AND CHANNEL ESTIMATION**

(75) Inventors: **Ravi Narasimhan**, Los Altos, CA (US); **Hemanth Sampath**, Sunnyvale, CA (US); **Hsiao-Cheng Tang**, Milpitas, CA (US)

(73) Assignee: **Marvell International Ltd.**, Hamilton (BM)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 617 days.

(21) Appl. No.: **10/912,829**

(22) Filed: **Aug. 5, 2004**

Related U.S. Application Data

(60) Provisional application No. 60/572,934, filed on May 19, 2004.

(51) **Int. Cl.**
H04B 1/69 (2006.01)
H04B 1/04 (2006.01)

(52) **U.S. Cl.** **375/148**; 375/299; 455/132

(58) **Field of Classification Search** 375/148, 375/347, 349, 299, 346, 348; 324/614; 455/132, 455/101

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0136313	A1 *	7/2004	Goldstein et al.	370/203
2005/0180312	A1 *	8/2005	Walton et al.	370/208
2005/0195733	A1 *	9/2005	Walton et al.	370/208
2006/0252386	A1 *	11/2006	Boer et al.	455/101

OTHER PUBLICATIONS

IEEE Std 802.11a-1999 (R2003), Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications,

High-speed Physical Layer in the 5 GHz Band, Jun. 12, 2003, pp. 7-8.*

van Nee, Richard, A new OFDM standard for high rate wireless LAN in the 5 GHz band; Vehicular Technology Conference, 1999. VTC 1999—Fall. IEEE VTS 50th vol. 1, Sep. 19-22, 1999 pp. 258-262 discloses a system with relevance to claims 1-60.*

IEEE Computer Society, "Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications", IEEE Std 802.11—First Edition, 1999.

IEEE Computer Society, "Supplement to IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: High-speed Physical Layer in the 5 GHz Band", IEEE Std 802.11a—1999 (Supplement to IEEE Std 802.11-1999)

IEEE Computer Society, "Supplement to IEEE Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Higher-speed Physical Layer Extension in the 2.4 GHz Band", IEEE Std 802.11b-1999 (Supplement to IEEE Std 802.11-1999).

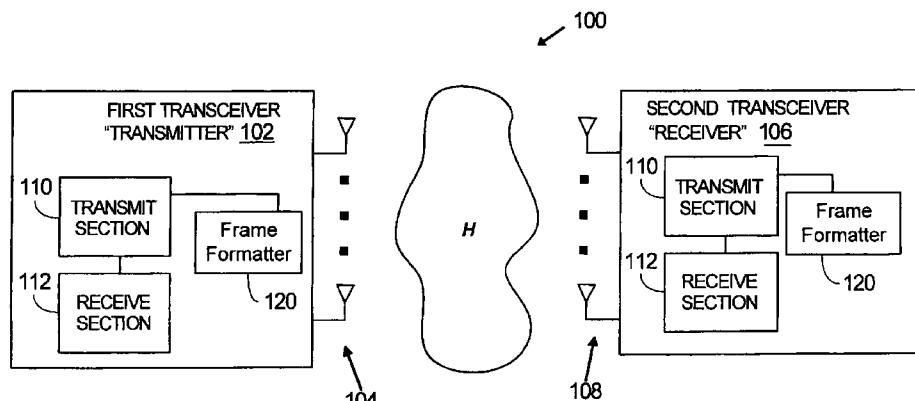
(Continued)

Primary Examiner—Khai Tran

(57) **ABSTRACT**

A receiver in a MIMO-OFDM system may process OFDM symbols received on a number (M_R) of receive antennas. The system may utilize a MIMO-OFDM frame format that includes additional long training OFDM symbols, for training additional antennas and for link adaptation, and a header with an additional SIGNAL symbol to indicate MIMO-OFDM-specific information.

50 Claims, 8 Drawing Sheets



OTHER PUBLICATIONS

IEEE Computer Society, “*IEEE Standard for Information Technology—DRAFT Supplement to Standard [for] Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific*

Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher Data Rate Extension in the 2.4 GHz Band”, IEEE P802.11g/D8.2, Apr. 2003.

* cited by examiner

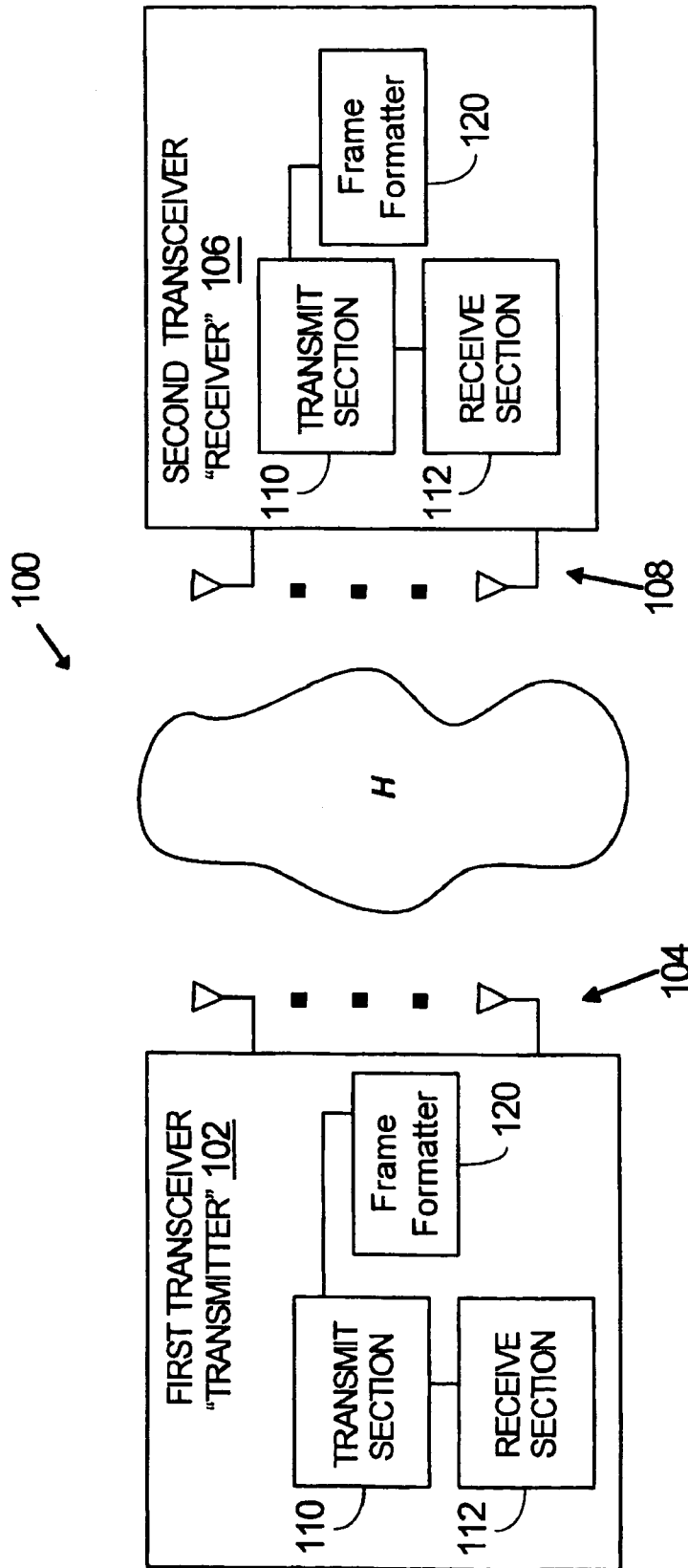


FIG. 1

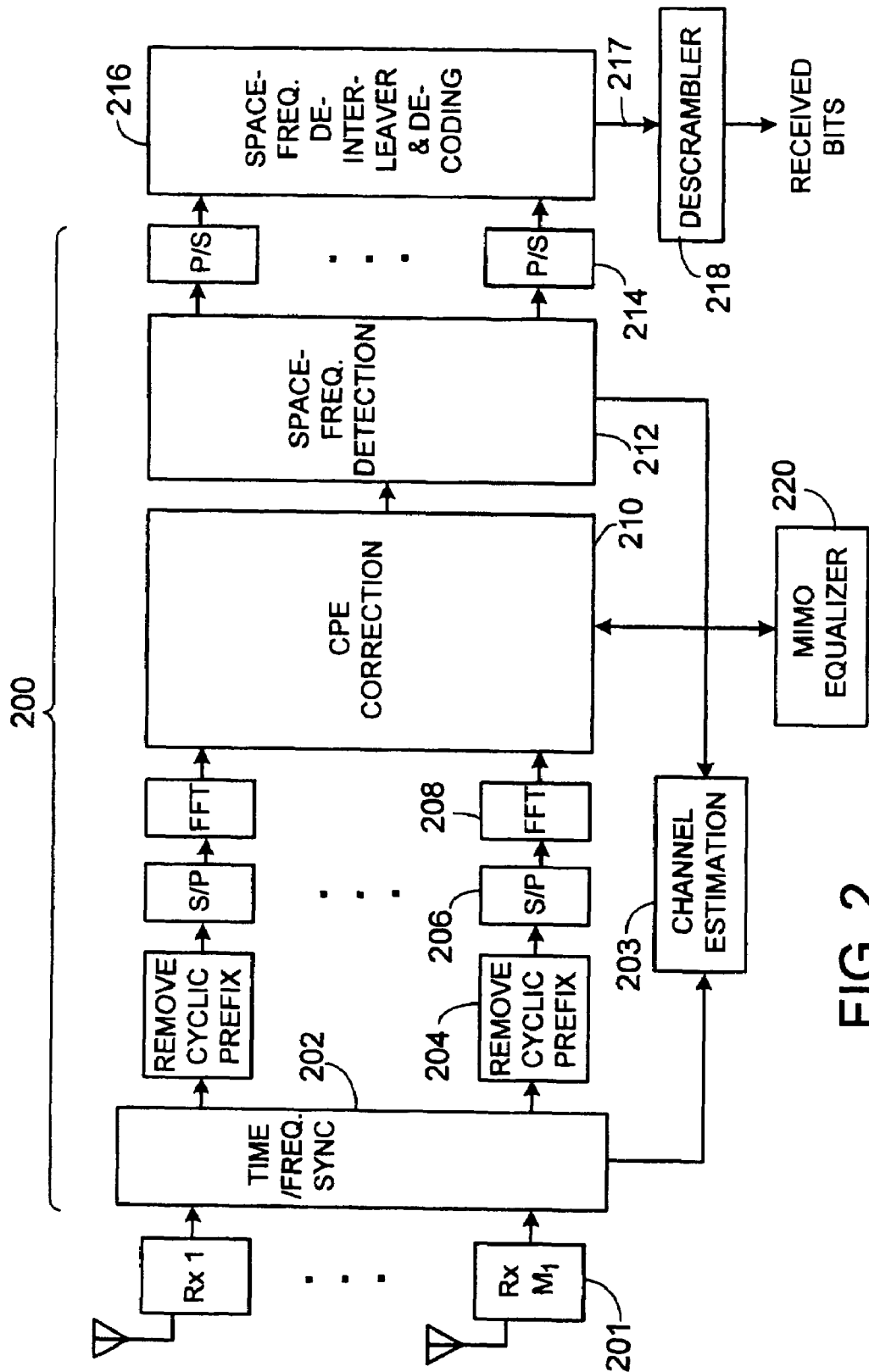


FIG. 2

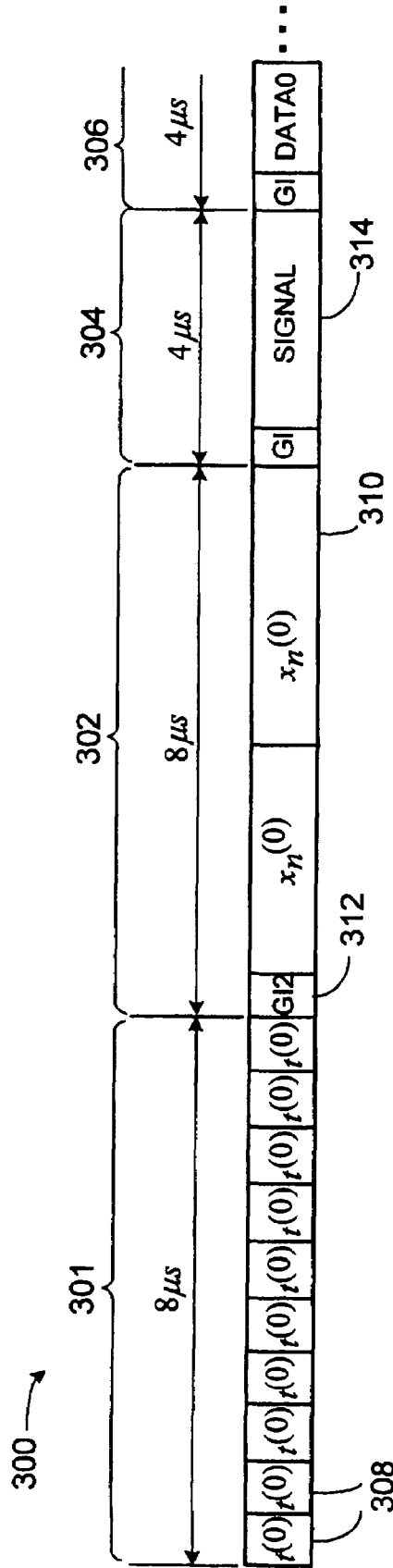


FIG. 3

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.