



US007650152B2

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

(10) **Patent No.:** **US 7,650,152 B2**  
(45) **Date of Patent:** **\*Jan. 19, 2010**

(54) **MULTI-CARRIER COMMUNICATIONS WITH ADAPTIVE CLUSTER CONFIGURATION AND SWITCHING**

(75) Inventors: **Xiaodong Li**, Bellevue, WA (US); **Hui Liu**, Clyde Hill, WA (US); **Wenzhong Zhang**, Bellevue, WA (US); **Kemin Li**, Bellevue, WA (US)

(73) Assignee: **Adaptix, Inc.**, Carrollton, TX (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/931,385**

(22) Filed: **Oct. 31, 2007**

(65) **Prior Publication Data**

US 2008/0219363 A1 Sep. 11, 2008

**Related U.S. Application Data**

(63) Continuation of application No. 11/592,084, filed on Nov. 2, 2006, now Pat. No. 7,379,742, which is a continuation of application No. 09/837,701, filed on Apr. 17, 2001, now Pat. No. 7,146,172, which is a continuation-in-part of application No. 09/738,086, filed on Dec. 15, 2000, now Pat. No. 6,947,748.

(51) **Int. Cl.**  
**H04Q 7/20** (2006.01)

(52) **U.S. Cl.** ..... **455/452.1**; 455/447; 455/450; 455/452.2; 455/453; 370/343; 370/347; 375/276

(58) **Field of Classification Search** ..... 455/452.1, 455/447, 450, 452.2, 453; 370/343, 347; 375/276

See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,355,411 A 10/1982 Reudink et al.  
4,670,889 A 6/1987 Hewitt et al.  
5,038,399 A 8/1991 Bruckert  
5,239,676 A \* 8/1993 Strawczynski et al. .... 455/437

(Continued)

**FOREIGN PATENT DOCUMENTS**

CN 1245623 2/2000

(Continued)

**OTHER PUBLICATIONS**

Bender et al., CDMA/HDR: A Bandwidth-Efficient High-Speed Wireless Data Service for Nomadic Users, IEEE Communications Magazine, Jul. 2000, pp. 70-87

(Continued)

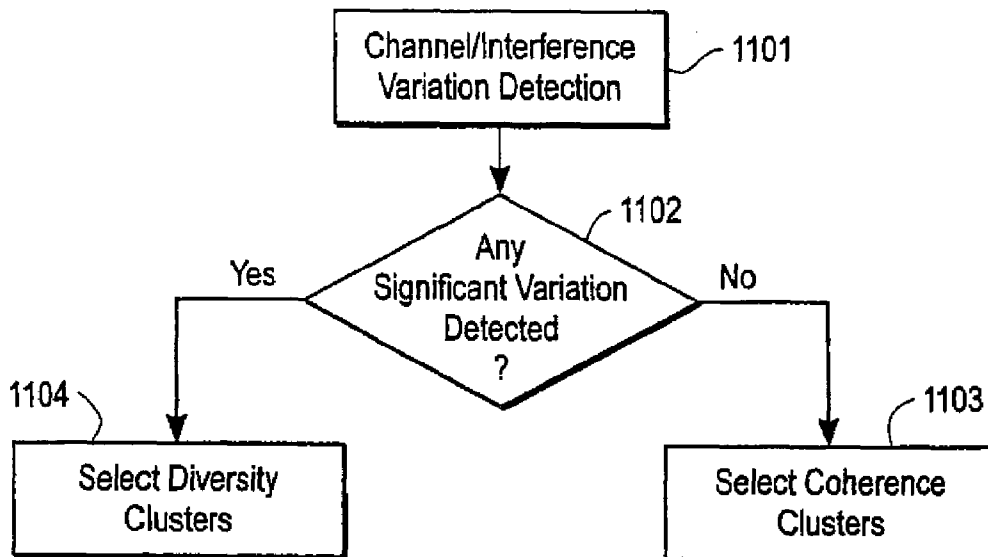
*Primary Examiner*—Stephen M D'Agosta

(74) *Attorney, Agent, or Firm*—Fullbright & Jaworski, L.L.P.

(57) **ABSTRACT**

A method and apparatus for allocating subcarriers in an orthogonal frequency division multiple access (OFDMA) system is described. In one embodiment, the method comprises allocating at least one diversity cluster of subcarriers to a first subscriber and allocating at least one coherence cluster to a second subscriber.

**19 Claims, 7 Drawing Sheets**



U.S. PATENT DOCUMENTS

5,280,630	A	1/1994	Wang	6,463,096	B1	10/2002	Raleigh et al.
5,282,222	A	1/1994	Fattouche et al.	6,473,467	B1	10/2002	Wallace et al.
5,437,054	A	7/1995	Rappaport et al.	6,477,158	B1	11/2002	Take et al.
5,471,647	A	11/1995	Gerlach et al.	6,487,253	B1	11/2002	Jones, IV et al.
5,479,447	A	12/1995	Chow et al.	6,493,331	B1	12/2002	Walton et al.
5,491,837	A	2/1996	Haartsen	6,496,490	B1	12/2002	Andrews et al.
5,504,775	A	4/1996	Chouly et al.	6,501,785	B1	12/2002	Chang et al.
5,507,034	A	4/1996	Bodin et al.	6,526,281	B1	2/2003	Gorsuch et al.
5,515,378	A	5/1996	Roy, III et al.	6,539,233	B1	3/2003	Taketsugu et al.
5,555,268	A	9/1996	Fattouche et al.	6,545,997	B1	4/2003	Bohnke et al.
5,588,020	A	12/1996	Schilling	6,553,001	B1	4/2003	Indira
5,634,199	A	5/1997	Gerlach et al.	6,553,234	B1	4/2003	Florea
5,708,973	A	1/1998	Ritter et al.	6,567,383	B1	5/2003	Bohnke et al.
5,726,978	A	3/1998	Frodigh et al.	6,567,387	B1	5/2003	Dulin et al.
5,732,353	A	3/1998	Haartsen	6,574,476	B1	6/2003	Williams
5,734,967	A	3/1998	Kotzin et al.	6,600,776	B1	7/2003	Alamouti et al.
5,764,699	A	6/1998	Needham et al.	6,654,612	B1	11/2003	Avidor et al.
5,774,808	A	6/1998	Sarkioja et al.	6,657,949	B1	12/2003	Jones, IV et al.
5,822,372	A	10/1998	Emami	6,693,884	B1*	2/2004	Gutowksi ..... 370/335
5,839,074	A	11/1998	Plehn et al.	6,694,147	B1	2/2004	Viswanath et al.
5,867,478	A	2/1999	Baum et al.	6,699,784	B2	3/2004	Xia et al.
5,884,145	A	3/1999	Haartsen	6,701,129	B1	3/2004	Hashem et al.
5,886,988	A	3/1999	Yun et al.	6,726,297	B1	4/2004	Uesugi et al.
5,887,245	A	3/1999	Lindroth et al.	6,760,882	B1	7/2004	Catreux et al.
5,909,436	A	6/1999	Engstrom et al.	6,782,037	B1	8/2004	Krishnamoorthy et al.
5,914,933	A	6/1999	Cimini et al.	6,788,349	B2	9/2004	Wu et al.
5,933,421	A	8/1999	Alamouti et al.	6,795,424	B1	9/2004	Kapoor et al.
5,956,642	A	9/1999	Larsson et al.	6,834,045	B1	12/2004	Lappetelainen et al.
5,973,642	A	10/1999	Li et al.	6,862,272	B2	3/2005	Dulin et al.
5,991,273	A	11/1999	Abu-Dayya et al.	6,870,808	B1	3/2005	Liu et al.
6,005,876	A	12/1999	Cimini, Jr. et al.	6,904,283	B2*	6/2005	Li et al. .... 455/450
6,009,332	A	12/1999	Haartsen	6,907,244	B2	6/2005	Santhoff et al.
6,009,553	A	12/1999	Martinez et al.	6,920,122	B1	7/2005	Hanaoka et al.
6,023,622	A	2/2000	Plaschke et al.	6,922,445	B1	7/2005	Sampath et al.
6,026,123	A	2/2000	Williams	6,928,120	B1	8/2005	Zhang
6,038,450	A	3/2000	Brink et al.	6,944,120	B2	9/2005	Wu et al.
6,041,237	A	3/2000	Farsakh et al.	6,947,748	B2	9/2005	Li et al.
6,052,594	A	4/2000	Chuang et al.	6,985,432	B1	1/2006	Hadad et al.
6,061,568	A	5/2000	Dent	6,996,075	B2	2/2006	Santhoff et al.
6,064,692	A	5/2000	Chow	6,996,100	B1	2/2006	Haartsen
6,064,694	A	5/2000	Clark et al.	7,047,011	B1	5/2006	Wikman et al.
6,067,290	A	5/2000	Paulraj et al.	7,072,315	B1	7/2006	Liu et al.
6,091,717	A	7/2000	Honkasalo et al.	7,095,719	B1	8/2006	Wilhelmsson et al.
6,108,374	A	8/2000	Balachandran et al.	7,133,352	B1	11/2006	Hadad
6,111,919	A	8/2000	Yonge, III	7,133,380	B1	11/2006	Winters et al.
6,131,016	A	10/2000	Greenstein et al.	7,146,172	B2*	12/2006	Li et al. .... 455/452.1
6,141,565	A	10/2000	Feuerstein et al.	7,203,191	B2	4/2007	Garcia-Luna-Aceves et al.
6,144,696	A	11/2000	Shively et al.	7,230,908	B2	6/2007	Vanderaar et al.
6,192,026	B1	2/2001	Pollack et al.	7,373,151	B1	5/2008	Ahmed
6,208,663	B1	3/2001	Schramm et al.	7,379,742	B2*	5/2008	Li et al. .... 455/452.1
6,226,320	B1	5/2001	Hakkinen et al.	2002/0114269	A1	8/2002	Onggosanusi et al.
6,276,297	B1	8/2001	van den Berg et al.	2003/0067890	A1	4/2003	Goel et al.
6,282,185	B1	8/2001	Hakkinen et al.	2003/0169681	A1	9/2003	Li et al.
6,298,092	B1	10/2001	Heath, Jr. et al.	2003/0169824	A1	9/2003	Chayat
6,304,593	B1	10/2001	Alouini et al.	2003/0211831	A1	11/2003	Xu et al.
6,307,851	B1	10/2001	Jung et al.	2005/0025099	A1	2/2005	Heath et al.
6,327,472	B1	12/2001	Westroos et al.				
6,330,460	B1	12/2001	Wong et al.				
6,351,499	B1	2/2002	Paulraj et al.				
6,351,643	B1	2/2002	Haartsen				
6,366,195	B1	4/2002	Harel et al.				
6,377,632	B1	4/2002	Paulraj et al.				
6,377,636	B1	4/2002	Paulraj et al.				
6,400,699	B1	6/2002	Airy et al.				
6,404,783	B1	6/2002	Cimini, Jr. et al.				
6,405,044	B1	6/2002	Smith et al.				
6,405,048	B1	6/2002	Haartsen				
6,411,186	B1	6/2002	Lilleberg et al.				
6,415,153	B1	7/2002	Liew				

FOREIGN PATENT DOCUMENTS

DE	198 00 953	C1	7/1999
EP	0 869 647		10/1998
EP	0 869 647	A2	10/1998
EP	0882377	B1	12/1998
EP	0 926 912	A2	6/1999
EP	0 929 202	A1	7/1999
EP	0999658		5/2000
FR	2 777 407	A1	10/1999
GB	2 209 858	A	5/1989
JP	1-317035		12/1989
JP	06029922		2/1994
JP	7-322219		12/1995

JP	11-308153	11/1999
KR	1999-28244	4/1999
WO	WO-96/19055	6/1996
WO	WO-97/01256	1/1997
WO	WO-98/16077 A2	4/1998
WO	WO-98/30047 A1	7/1998
WO	WO-00/004121	6/2000
WO	WO-02 49305 A2	6/2002

## OTHER PUBLICATIONS

- English translation of Japanese Office Action for Application No. 2002-550683, dispatched May 7, 2007, 2 ppgs.
- English translation of Japanese Office Action for Application No. 2002-550747, dispatched May 21, 2007, 4 ppgs.
- European Office Action from Application No. 01 986 165.7, dated Mar. 29, 2007, 5 ppgs.
- Farsakh, C. et al., "Maximizing the SDMA Mobile Radio Capacity Increase by DOA Sensitive Channel Allocation," *Wireless Personal Communications*, Kluwer Academic Publishers, NL, vol. 11, No. 1. Oct. 1999, pp. 63-76, XP000835062, ISSN: 0929-6212.
- Frullone et al., PRMA Performance in Cellular Environments with Self-Adaptive Channel Allocation Strategies, *IEEE Transactions on Vehicular Technology*, Nov. 1996, pp. 657-665, vol. 45, No. 4.
- Farsakh, Cristof and Nossek, Josef A., On the Mobile Radio Capacity Increase through SDMA, no date (after 1997).
- Gruenheid, R. et al.: "Adaptive Modulation and Multiple Access for the OFDM Transmission Technique," *Wireless Personal Communications*, Kluwer Academic Publishers, NL, vol. 13, NR. 1/2, Year 2000, pp. 5-13 XP000894156, ISSN: 0929-6212.
- Kapoor, S. et al.: "Adaptive Interference Suppression in Multiuser Wireless, OFDM Systems Using Antenna Arrays," *IEEE Transactions on Signal Processing*, vol. 47, No. 12, Dec. 1999, pp. 3381-3391, XP000935422, IEEE, NY, USA, ISSN: 1053-587X.
- Kinugawa, Y. et al.: "Frequency and Time Division Multiple Access with Demand-Assignment Using Multicarrier Modulation for Indoor Wireless Communications Systems," *IEICE Transactions on Communications*, Institute of Electronics Information and Comm. Eng. Tokyo, Japan, vol. E77-B, NR. 3, Mar. 1994, pp. 396-402, XP000451014, ISSN: 0916-8516.
- Motegi, M. et al.: Optimum Band Allocation According to Subband Condition for BST-OFDM 11th IEEE International Symposium on Personal Indoor and Mobile Radio Communications, vol. 2, Sep. 18-21, 2000, pp. 1236-1240, XP002213669, Piscataway, NJ, USA, ISBN: 0-7803-6463-5.
- Nogueroles, R. et al.: Improved Performance of a Random OFDMA Mobile Communication System: *Vehicular Technology Conference*, 1998. VTC 98. 48th IEEE Ottawa, Ontario, Canada, May 18-21, 1998, pp. 2502-2506, XP010288120, ISBN: 0-7803-4320-4.
- Office Action issued for Korean Patent Application 2003-7007961 dated Sep. 27, 2006.
- Shad et al., Indoor SDMA Capacity Using a Smart Antenna Base Station, 1997, IEEE, pp. 868-872.
- Tsoulos, G.V., Smart Antennas for Mobile Communication System: Benefits and Challenges, *Electronics & Communication Engineering Journal*, Apr. 1999, pp. 84-94.
- Vittoria Mignone et al. "CD3-OFDM: A Novel Demodulation Scheme for Fixed and Mobile Receivers," *IEEE Transactions on Communications*, Sep. 1996, vol. 44, No. 9.
- Ward, James and Compton, R. Ted, Jr., High Throughput Slotted ALOHA Packet Radio Networks with Adaptive Arrays, *IEEE Transactions on Communications*, Mar. 1993, pp. 460-470, vol. 41, No. 3.
- Wong, C. Y., et al., Multiuser OFDM With Adaptive Subcarrier, Bit, and Power Allocation, *IEEE Journal on Selected Areas in Communications*, Oct. 1999, IEEE Inc., New York, USA, vol. 17, No. 10, pp. 1747-1758, XP000855475.
- Xu, Guanghan and Li, San-Qi, Throughput Multiplication of Wireless Lans for Multimedia Services: SDMA Protocol Design, 1994 IEEE, pp. 1326-1332.
- Ye Li, et al.: "Clustered OFDM with channel estimation for high rate wireless data," *Mobile Multimedia Communications*, 1999.
- English Translation of the Office Action issued for Chinese Patent Application No. 200610081062.5, dated Apr. 3, 2009; 7 pages.
- Goldsmith et al., "Adaptive Coded Modulation for Fading Channels", *IEEE Transactions on Communications*, vol. 46, No. 5, May 1998, 8 pgs.
- Goldsmith et al., "Variable-Rate Variable-Power MQAM for Fading Channels", *IEEE Transactions on Communications*, vol. 45, No. 10, Oct. 1997, 13 pgs.
- Czylwik, Andreas, "Adaptive Ofdm for Wideband Radio Channels", *IEEE 0/7803-3336-5/96*, copyright 1996, 6 pgs.
- Doufexi et al., "A Comparison of Hiperlan/2 and IEEE802.11a Physical and MAC Layers", *IEEE 0/7803-6684-0/00*, copyright 2000, 7 pgs.
- Arogyaswanni et al., "A Taxonomy of Space-Time Processing for Wireless Networks", *IEEE* vol. 143, No. 1, Feb. 1998, 21 pgs.
- Wang et al., "Dynamic Channel Resource Allocation in Frequency Hopped Wireless Communication Systems", *IEEE 0-7803-2015--8/94*, copyright 1994, 1 pg.
- Wong et al., "A Real-Time Sub-Carrier Allocation Scheme for Multiple Access Downlink OFDM Transmission", *IEEE 0-7803-5435-4/99*, copyright 1999, 5 pgs.
- Wong et al., "Multiuser OFDM wit Adaptive Subcarrier, Bit and Power Allocation", *IEEE* vol. 17, No. 10, Oct. 1999, 12 pgs.
- Wong et al., "Multiuser Subcarrier Allocation for OFDM Transmission Using Adaptive Modulation", *IEEE 0-7803-5565-2/99*, copyright 1999, 5 pgs.
- Sung et al., "User Speed Estimation and Dynamic Channel Allocation in Hierarchical Cellular System", *IEEE 0-7803-1927-3/94*, copyright 1994, 5 pgs.
- Kivanc et al., "Subcarrier Allocation and Power control for Ofdma", *IEEE 0-7803-6514-3/00*, copyright 2000, 5 pgs.
- Grunheld et al., "Adaptive Modulation and Multiple Access for the OFDM Transmission Technique", *Wireless Personal Communications* 13: 5-13, dated 2000, 9 pgs.
- Viswanathan et al., "Adaptive Coded Modulation Over Slow Frequency-Selective Fading Channels", *IEEE 0-7803-5585-2/99*, copyright 1999, 5 pgs.
- Sari, Hikmet, "Trends and Challenges in Broadband Wireless Access", *IEEE 0-7803-6684-0/00*, copyright 2000, 5 pgs.
- Sari et al., "An Analysis of Orthogonal Frequency-Division Multiple Access", *IEEE 0-7803-4198-8/97*, copyright 1997, 5 pgs.
- Toba et al., "A Demand-Assign Optical Frequency-Division-Multiple-Access Star Network", *Journal of Lightwave Technology*, vol. 11, No. 56, May/June. 1993, 7 pgs.
- Katzela et al., "Channel Assignment Schemes for Cellular Mobile Telecommunication Systems: A Comprehensive Survey", *IEEE 1070-9916/96*, copyright 1996, 22 pgs.
- van de Beek et al., "A Time and Frequency Synchronization Scheme for Multiuser OFDM", *IEEE* vol. 17, No. 11, Nov. 1999, 16 pgs.
- van de Beek et al., "On Channel Estimation in OFDM Systems", *Proceedings of Vehicular Technology Conference (VTC 95)* vol. 2, Sep. 1995, 6 pgs.
- Chuang et al., "Wideband Wireless Data Access Based on OFDM and Dynamic Packet Assignment", *IEEE 0-7803-5668-3/99*, copyright 1999, 5 pgs.
- Sathanathan et al., "Analysis of OFDM in the Presence of Frequency Offset and a Method to Reduce Performance Degradation", *0-7803-6451-1/00*, copyright 2000, 5 pgs.
- Keller et al., "Adaptive Modulation Techniques for Duplex OFDM Transmission", *IEEE* vol. 49, No. 5, Sep. 2000, 14 pgs.
- Li et al., "A New Blind Receiver for Downlink DS-CDMA Communications", *IEEE* vol. 3, No. 7, Jul. 1999, 3 pgs.
- Li et al., "Clustered OFDM with Channel Estimation for High Rate Wireless Data", 1999 IEEE International Workshop, Nov. 15-17, 1999, 9 pgs.
- Liu et al., "Efficient Network Utilization for Multimedia Wireless Networks", C.G. Omidyar (Ed.), *MWCN 2000*, copyright 2000, 15 pgs.
- Luise et al., "Carrier Frequency Acquisition and Tracking for OFDM Systems", *IEEE 0090-6778/96*, copyright 1996, 9 pgs.
- Ericson et al., "Evaluation of the Mixed Service Ability for Competi-

- Wahlqvist et al., "Capacity Comparison of an OFDM Based Multiple Access System Using Different Dynamic Resource Allocation", IEEE 0-7803-3659-3/97, copyright 1997, 5 pgs.
- Vanderaar, Mark et al., "Provisional Application", dated Jul. 24, 2000, 11 pgs.
- Johnsson, Martin, "HiperLAN/2 - The Broadband Radio Transmission Technology Operating in the 5 GHz Frequency Band", Global Forum, 1999, 22 pgs.
- Olfat et al., "Adaptive Beamforming and Power Allocation for OFDM Over Wireless Networks", IEEE 0-7803-5148-7/98, copyright 1998, 5 pgs.
- Wahlqvist et al., "A Conceptual Study of OFDM-Based Multiple Access Schemes, Part 1: Air Interface Requirements", Telia Research AB, Jun. 5, 1996, 6 pgs.
- Wahlqvist et al., Description of Telias OFDM Based Proposal (Working document in the OFDM concept group) Telia, ETSI STC SMG2#22, May 12-16, 1997, 22 pgs.
- Mehta et al., "Performance Analysis of Link Adaptation in Wireless Data Networks", Department of Electrical Engineering, Stanford University, Mar. 6, 2000, 15 pgs.
- Author Unknown, "Part 11: Wireless Lan Medium Access Control (MAC) and Physical Layer (PHY) specifications: High-Speed Physical Layer in the 5 GHz Band", IEEE Supplement, Sep. 16, 1999, 90 pgs.
- Robertson et al., "The Effects of Doppler Spreads in OFDM(A) Mobile Radio Systems", IEEE 0/7803-5435-4, copyright 1999, Institute for Communications Technology, German Aerospace Center (DLR), 5 pgs.
- Knopp et al., "Information Capacity and Power Control in Single-Cell Multiuser Communications", IEEE 0/7803-2486-2/95, copyright 1995, 5 pgs.
- Rohling et al., "Adaptive Coding and Modulation in an OFDM-TDMA Communication System", IEEE 0/7803-4320-4/98, copyright 1998, 4 pgs.
- Nogueroles et al., "Improved Performance of a Random OFDMA Mobile Communication System", IEEE 0/7803-4320-4/98, copyright 1998, 5 pgs.
- Nogueroles et al., "Performance of a Random OFDMA System for Mobile Communications", IEEE 0/7803-3893-6/98, copyright 1998, 7 pgs.
- van Nee et al., "OFDM for Wireless Multimedia Communications", Artech House Universal Personal Communications, copyright 2000, 14 pgs.
- Heath et al., "Coordinated Training and Transmission for Improved Interference Cancellation in a Cellular Network", IEEE 0-803-6514-3/00, copyright 2000, 7 pgs.
- Rohling et al., "Performance Comparison of Different Multiple Access Schemes for the Downlink of an OFDM Communication System", IEEE 0/7803-3659-3/97, copyright 1997, 5 pgs.
- Sartenaer et al., "Resource Allocation for Frequency-Selective Multiple Access Channels with Adaptive QAM Modulation", IEEE 0/7803-6684-00, copyright 2000, 8 pgs.
- Seong-Jun Oh et al. "Adaptive Resource Allocation in Power Constrained Cdma Mobile Networks", IEEE 0/7803-5668-3/99, copyright 1999, 5 pgs.
- Slawomir et al., "Multiuser Subcarrier Allocation for QoS Provision in the OFDMA Systems", IEEE 0/7803-7467-3/02, copyright 2002, 5 pgs.
- Sollenberger et al., "Receiver Structure for Multiple Access OFDM", IEEE 0/7803-5565-2/99, copyright 1999, 5 pgs.
- Papavassiliou et al., "Joint Optimal Channel Base Station and Power Assignment for Wireless Access", Polytechnic University, Published Jun. 17, 1996, 35 pgs.
- Maehata et al., "DSRC Using OFDM for Roadside-Vehicle Communication System", IEEE 0-7803-5718-3/00, copyright 2000, 5 pgs.
- Keller et al., "Adaptive Modulation Techniques for Duplex OFDM Transmission", Department of Electronics and Computer Science, University of Southampton, Jun. 7, 1999, 14 pages.
- Tufvesson et al., "Pilot Assisted Channel Estimation for OFDM in Mobile Cellular Systems", Department of Applied Electronics, Lund University, VTC 1997, 5 pgs.
- Rhee et al., "Increase in Capacity of Multiuser OFDM System Using Dynamic Subchannel Allocation", IEEE 0/7803-5718-3/00, copyright 2000, 5 pgs.
- Li et al., "Maximum-Likelihood Estimation of OFDM Carrier Frequency Offset for Fading Channels", IEEE 1058-6393/98, copyright 1998, 5 pgs.
- Li et al., "M-Sequences for OFDM Peak-to-Average Power Ration Reduction and Error correction", Electronics Letters, vol. 33, No. 7, Mar. 27, 1997, 2 pgs.
- Li et al., "Effects of Clipping and Filtering on the Performance of OFDM", IEEE Conference on Vehicular Technology, 1997, 3 pgs.
- Li et al., "Effects of Clipping and Filtering on the Performance of OFDM", IEEE 0-7803-3659-3/97, copyright 1997, 5 pgs.
- Tang et al., "An Adaptive Modulation Scheme for Simultaneous Voice and Data Transmission Over Fading Channels", IEEE Vehicular Technology Conference (VTC '98), draft dated Dec. 1, 1997, 32 pgs.
- Matsui et al., "OFDMA/TDD Packet Transmission System with an Adaptive Subcarrier Selection Scheme for Asymmetric Wireless Communication Services", IEEE 0-803-6622-0/01, copyright 2001, 2 pgs.
- Li et al., "Channel Estimation for OFDM Systems with Transmitter Diversity in Mobile Wireless Channels", IEEE 0733-8716/99, copyright 1999, 11 pgs.

\* cited by examiner

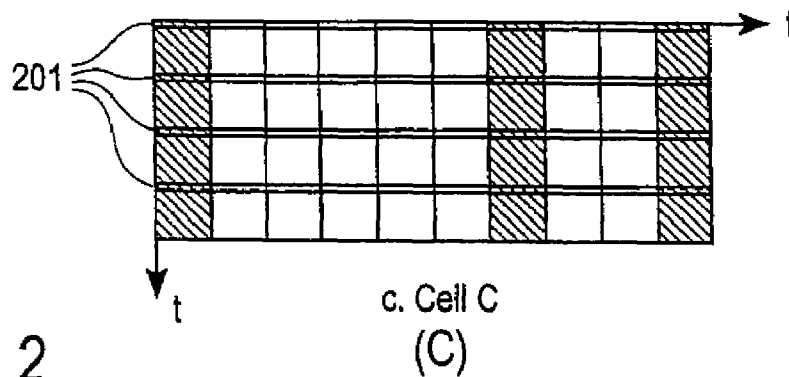
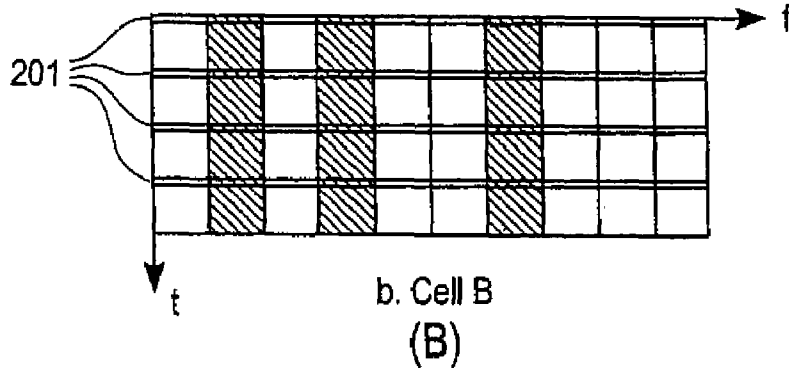
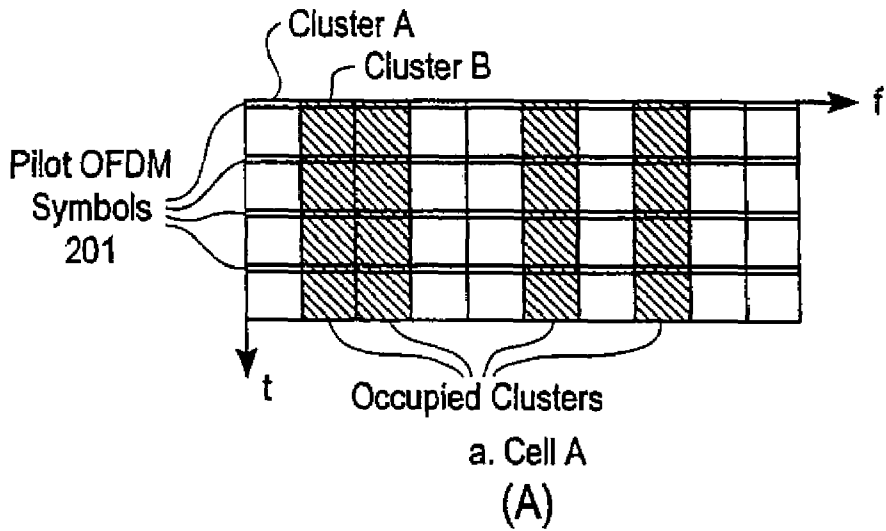
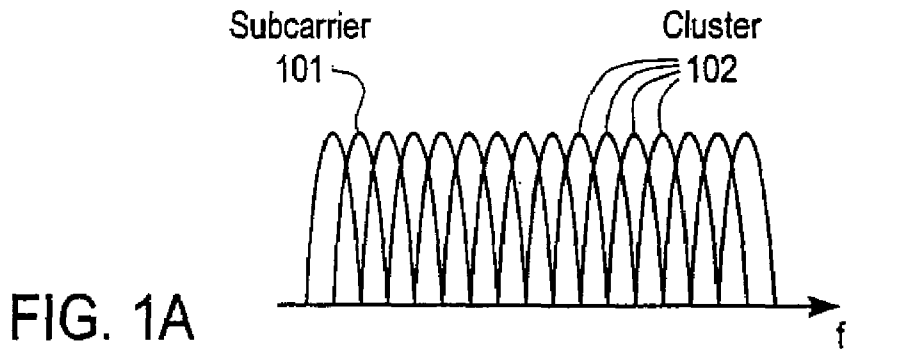


FIG. 2

# 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.