

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.,
SAMSUNG ELECTRONICS AMERICA, INC., GOOGLE LLC, and CISCO
SYSTEMS, INC.,

Petitioners

v.

XR COMMUNICATIONS, LLC D/B/A VIVATO TECH.

Patent Owner

Case IPR2022-00613

U.S. Patent No. 10,594,376

**DECLARATION OF ZHI DING, PH.D. IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT 10,594,376**

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	BACKGROUND AND QUALIFICATIONS	1
III.	MATERIALS REVIEWED	7
IV.	LEVEL OF ORDINARY SKILL IN THE ART.....	11
V.	RELEVANT LEGAL STANDARDS	12
VI.	TECHNICAL BACKGROUND	15
A.	Wireless Networks	15
B.	Antennas	18
C.	Smart/Adaptive Antennas	19
D.	Spatial Multiplexing	23
1.	Receive Beamforming.....	24
2.	Transmit Beamforming	26
VII.	OVERVIEW OF THE '376 PATENT	29
VIII.	OVERVIEW OF THE PRIOR ART	32
A.	Gerlach	32
B.	Barratt	42
C.	Okamoto	46
IX.	CLAIM CONSTRUCTION	47
X.	THE PRIOR ART DISCLOSES OR SUGGESTS ALL OF THE FEATURES FO THE CHALLENGED CLAIMS.....	47
A.	Grounds Challenging Claims 1-34 of the '376 patent.	47
B.	The Combination of Gerlach and Barratt Discloses or Suggests All of the Features of Claims 1-9, 12-18, and 22-34	48
1.	A Person Having Ordinary Skill in the Art Would Have Been Motivated to Combine Gerlach with Barratt.....	48
2.	Claim 1	51
3.	Claim 12	95
4.	Claim 22	97
5.	Claim 32	104

6. Claims 2, 13, 23, and 33.....	107
7. Claims 3, 14, 25, and 34.....	110
8. Claims 4, 15, and 26.....	111
9. Claims 5, 16, 24, and 27.....	113
10. Claims 6, 17, 28 and 29.....	115
11. Claims 7 and 18.....	117
12. Claims 8 and 9.....	118
13. Claim 30	121
14. Claim 31	123
C. Ground 2: Gerlach, Barratt, and Okamoto Render Obvious Claims 10-11 and 19-21.....	123
1. A Person Having Ordinary Skill in the Art Would Have Been Motivated to Combine Gerlach and Barratt with Okamoto	123
2. Claim 10	127
3. Claim 11	130
4. Claim 19	131
5. Claim 20	132
6. Claim 21	133
XI. CONCLUSION	134

I, Zhi Ding, declare as follows:

I. INTRODUCTION

1. I have been retained by Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., Google, LLC, and Cisco Systems, Inc. (collectively, “Petitioners”) as an independent expert consultant in this proceeding before the United States Patent and Trademark Office (“PTO”)

2. I am being compensated at a rate of \$725/hour for my services in this proceeding, which is my regular and customary rate.

3. My compensation is in no way contingent on the nature of my findings, the presentation of my findings in testimony or this declaration, or the outcome of this or any other proceeding. I have no other interest in this proceeding.

4. I have been asked to consider whether certain references disclose and/or suggest the features recited in claims 1-34 of U.S. Patent No. 10,594,376 (“the ’376 patent”) (EX-1001).¹ My opinions are set forth below.

II. BACKGROUND AND QUALIFICATIONS

5. I am an independent consultant. All of my opinions stated in this declaration are based on my own personal knowledge and professional judgment. In

¹ Where appropriate, I refer to exhibits I understand will be attached to the petition for *inter partes* review of the ’376 patent (the “Petition”).

forming my opinions, I have relied on my knowledge and experience in electrical engineering, computer science, digital wireless communications, wireless network design and optimization, and digital and array signal processing.

6. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth herein. A copy of my current curriculum vitae, which details my education and professional and academic experience, is included as EX-1004 in this proceeding. The following provides an overview of some of my experience that is relevant to the matters set forth in this declaration.

7. I presently serve as a Professor in the Department of Electrical and Computer Engineering at the University of California, Davis (“UC Davis”), a position I have held since my appointment on July 1, 2000. I also hold the title of Distinguished Professor since July 1, 2020. I am also a private technical consultant on various technologies related to information systems. I have over three decades of teaching and research experience on a wide range of topics related to communication systems and signal processing. Prior to UC Davis, I served full time as a faculty member at Auburn University from 1990 to 1998, and the University of Iowa from 1999 to 2000.

8. I earned my Bachelor of Engineering degree in 1982 in wireless engineering from the Nanjing Institute of Technology (later renamed as Southeast

University) in Nanjing, China. I earned my Master of Applied Science degree in 1987 in electrical engineering from the University of Toronto in Toronto, Canada. I earned my Ph.D. in 1990 in electrical engineering from Cornell University in Ithaca, New York.

9. My responsibilities as a Professor at UC Davis include classroom instruction on various topics of communication systems and signal analysis, as well as mentoring undergraduate students and supervising graduate students in their research and development efforts on various topics related to digital communications. I have directly supervised such research and development works ranging from signal detection to wireless networking. I have also directly supervised the completion of over 20 Masters theses and 25 Ph.D. dissertations on various topics related to digital communications.

10. Since 1990, I have been selected as the principal investigator of multiple highly competitive federal and local research grants, including sixteen major research projects supported by the National Science Foundation and two research projects funded by the U.S. Army Research Office. These competitive research projects focused on developing more efficient and effective digital communication transceivers, networks, and signal processing tools. I have also participated as co-principal investigator in several large-scale projects supported by the Defense Advanced Research Projects Agency (DARPA) with teams of

researchers. Additionally, I have applied for, and received support from, other federal, state, and industry sponsors.

11. I have published over 200 peer-reviewed research articles in premier international journals, in addition to over 240 refereed technical articles at top international conferences on communications and information technologies. In addition to these peer-reviewed technical works and book chapters, I have also written two books on communications technologies. My most recent book, coauthored with B.P. Lathi, is entitled, “Modern Digital and Analog Communication Systems,” 5th edition, and was published by the Oxford University Press in 2018. The 4th edition of this book (also coauthored with B.P. Lathi and published in 2009) had been widely adopted as an introductory textbook to communication systems.

12. In addition to the over 440 published technical papers that have been cited over 14,600 times according to Google Scholar, I am also co-inventor of four issued U.S. patents on communication technologies.

13. I am a member of the Institute of Electrical and Electronics Engineers (IEEE) and was elevated to the grade of Fellow in January 2003 for contributions made in signal processing for communication. The IEEE is the world’s largest professional society of engineers, with over 400,000 members in more than 160 countries. The IEEE has led the development of many standards for modern digital communications and networking, most notably, the IEEE 802 series of network

standards. The IEEE Grade of Fellow is conferred by the Boards of Directors upon a person with an extraordinary record of accomplishments in any of the IEEE fields of interest. The total number selected in any one year does not exceed one-tenth of one percent of the total voting Institute membership.

14. My services within the IEEE include the following positions:

- Chief Information Officer of the IEEE Communications Society from Jan. 2018 to present.
- General Chair of the 2016 IEEE International Conference on Acoustics, Speech, and Signal Processing, the flagship conference of the IEEE Signal Processing Society.
- Chair of the Steering Committee for the IEEE Transactions on Wireless Communications from 2008 to 2010.
- Distinguished Lecturer of the IEEE Communications Society from January 2008 to December 2009.
- Technical Program Chair of the 2006 IEEE Globecom, one of two flagship annual IEEE Communication Society conferences.
- Distinguished Lecturer of the IEEE Circuits and Systems Society from 2004 to 2005.
- Associate Editor of the IEEE Transactions on Signal Processing from 1994 to 1997 and from 2001 to 2004.

- Member of the IEEE Statistical Signal and Array Processing for Communications Technical Committee from 1993 to 1998.
- Member of the IEEE Signal Processing for Communications Technical Committee from 1998 to 2004.

15. In 2012, I received the annual Wireless Communications Technical Committee Recognition Award from the IEEE Communications Society, an award given to a person with a high degree of visibility and contribution in the field of “Wireless and Mobile Communications Theory, Systems, and Networks.” I am also the recipient of the 2020 Education Award from the IEEE Communications Society.

16. I have also served as a technical consultant for the telecommunication industry. For example, in 1995 I consulted for Analog Devices, Inc., on the development of the first generation DOCSIS cable modem systems. I have also consulted for other companies, including Nortel Networks and NEC US Laboratories. I worked as a visiting faculty research fellow at NASA Glenn Research Center in 1992 and at U.S. Air Force Wright Laboratory in 1993. I have served on multiple review panels of the National Science Foundation to evaluate competitive research proposals in the field of communication. I have also reviewed a large number of research proposals at the request of the National Science and Engineering Research Council (NSERC) of Canada as an expert panelist from 2010 to 2013, and

also at the request of the Research Grant Council (RGC) of Hong Kong as an external reviewer.

17. I have served as an expert witness or consulting expert on a number of matters related to intellectual property, mostly in the arena of telecommunications, including cellular communications, Wi-Fi technologies, Bluetooth, and optical communications. For example, since 2007, I have been engaged to assist in various litigations and legal disputes involving cellular, WiFi, and optical communication networks in terms of essentiality, infringement, and invalidity.

III. MATERIALS REVIEWED

18. The opinions contained in this declaration are based on the documents I reviewed, my professional judgement, as well as my education, experience, and knowledge regarding electrical engineering, computer science, digital wireless communications, wireless network design and optimization, and digital and array signal processing.

19. In forming my opinions expressed in this declaration, I reviewed the following materials:

- The '376 Patent (EX-1001)
- The File History of the '376 Patent (EX-1002)
- U.S. Patent No. 5,471,647 ("Gerlach") (EX-1005)
- U.S. Patent No. 5,592,490 ("Barratt") (EX-1006)

- G. Okamoto et al., “Evaluation of beamforming algorithm effectiveness for the smart wireless LAN system,” VTC '98. 48th IEEE Vehicular Technology Conference. Pathway to Global Wireless Revolution, 1998, pp. 1675-1679 vol.3 (“Okamoto”) (EX-1007)
- U.S. Patent No. 6,215,983 (“Dogan”) (EX-1010)
- U.S. Patent No. 6,067,290 (“Paulraj”) (EX-1011)
- R.H. Roy, “Application of Smart Antenna Technology in Wireless Communication Systems” in Mobile Networking with WAP. (2000) (“Roy”) (EX-1013)
- Excerpts from Stutzman, Warren and Gary Thiele. Antenna Theory and Design. 2nd Ed. John Wiley & Sons, Inc., 1998 (“Stutzman”) (EX-1014)
- Miller, Sandra K., “Facing the Challenge of Wireless Security,” Computer, Vol. 34, July 2001 (“Miller”) (EX-1015)
- Saliga, Stephen V., “An Introduction to IEEE 802.11 Wireless LANs”, 2000 IEEE Radio Frequency Integrated Circuits Symposium, pp. 11-14 (“Saliga”) (EX-1016)
- 802.11-1999 - Standard for Information Technology - Telecommunication 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, November 30, 1998 (“802.11”) (EX-1017)

- Gast, Matthew, 802.11 Wireless Networks: The Definitive Guide (Apr. 2002) (“Gast”) (EX-1019)
- P. Lehne & M. Petterson, “An overview of smart antenna technology for mobile communications systems”, IEEE Communications Surveys, Fourth Quarter 1999, Vol. 2, No. 4 (“Lehne”) (EX-1020)
- D. Gerlach and Arogyaswami Paulraj, "Base station transmitter antenna arrays with mobile to base feedback," Proceedings of 27th Asilomar Conference on Signals, Systems and Computers, 1993, pp. 1432-1436 vol.2, (“Gerlach 1993”) (EX-1021)
- A. U. Bhobe and P. L. Perini, “An overview of smart antenna technology for wireless communication,” in Proc. IEEE Aerosp. Conf., Mar. 2001, vol. 2, pp. 875–883. (“Bhobe”) (EX-1022)
- Excerpts from J. Litva, *Digital Beamforming in Wireless Communications*, Artech House (1996) (“Litva”) (EX-1023)
- Excerpts from J. Liberti and T. Rappaport, *Smart Antennas for Wireless Communications: IS-95 and Third Generation CDMA Applications* (1999) (“Liberti”) (EX-1024)

- Qualcomm MSM6000 Chipset Solution Data Sheet (“Qualcomm”) (EX-1025)
- U.S. Patent No. 5,371,734 (“Fisher”) (EX-1026)
- J. Thomson et al., *"An integrated 802.11a baseband and MAC processor,"* in 2002 IEEE International Solid-State Circuits Conference, Digest of Technical Papers. (“Thomson”) (EX-1027)
- Texas Instruments, *"TI Extends Wireless LAN Coverage Area by 70 Percent with New IEEE 802.11b Chip and Reference Designs"* (June 4, 2001) (<https://www.ti.com/sc/docs/news/2001/01112.htm>) (“Texas Instruments”) (EX-1028)
- U.S. Patent Application Publication 2002/0119754 (“Wakutsu”) (EX-1029)
- U.S. Patent Application Publication 2003/0008684 (“Ferris”) (EX-1030)
- U.S. Patent No. 6,208,627 (“Menon”) (EX-1031)

And any other materials I refer to in this declaration in support of my opinions.

20. All of the opinions contained in this declaration are based on the documents I reviewed and my knowledge and professional judgment. My opinions have also been guided by my appreciation of how a person having ordinary skill in the art would have understood the claims and the specification of the ’376 patent at

the time of the alleged invention, which I have been asked to initially consider as early November 2002. My opinions reflect how one of ordinary skill in the art would have understood the '376 patent, the prior art to the patent, and the state of the art at the time of the alleged invention.

21. Based on my experience and expertise, it is my opinion that certain references disclose and/or suggest all the features recited in claims 1-34 (“challenged claims”) of the '376 patent, as I discuss in detail below.

IV. LEVEL OF ORDINARY SKILL IN THE ART

22. I have been informed and understand that, in the context of an invalidity analysis, a person having ordinary skill in the art is a hypothetical person who looks to prior art at the time of the invention. I further understand that the factors that may be considered in determining the level of ordinary skill include: (1) the problems encountered in the art; (2) the prior art solutions to the problems encountered in the art; (3) the rapidity of innovation; (4) the sophistication of the technology; and (5) the education level of active workers in the field. I understand that these factors need not all be considered for the analysis and that one or more of these factors may control.

23. I have been informed that the following was proposed by parties in related litigation: A person having ordinary skill in the art would have had at least a Bachelor’s degree in Electrical Engineering or a related field, and three to four years

of work experience in wireless communications, or a Master's degree and at least two years of work experience in wireless communications.

24. I was asked to provide my opinion on the level of one of ordinary skill in the art with respect to the alleged invention of the '376 patent as of early November 2002. Based on my consideration of the factors above, I agree.

25. As of early November 2002, I met, and in fact exceeded, the qualifications of a person having ordinary skill in the art. To be clear, all of my opinions in this declaration are from the perspective of one of ordinary skill in the art as I have defined it here during the relevant timeframe.

V. RELEVANT LEGAL STANDARDS

26. I am not an attorney and offer no legal opinions, but in the course of my work, I have had experience studying and analyzing patents and patent claims from the perspective of a person skilled in the art.

27. For the purposes of this declaration, I have been informed about certain aspects of the law that are relevant to forming my opinions. My understanding of the law is as follows:

28. Petitioners' counsel has informed me that for the prior art to inherently disclose a claimed limitation, the prior art need not expressly disclose the limitation, so long as the claimed limitation necessarily flows from a disclosure in the prior art. I also understand that it is acceptable to examine evidence outside the prior art

reference (extrinsic evidence) in determining whether a feature, while not expressly discussed in the reference, is necessarily present in that reference.

29. Petitioners' counsel has informed me that a patent claim can be considered to have been obvious to a person having ordinary skill in the art at the time the application was filed. I am informed that this means that, even if all of the requirements of a claim are not found in a single prior art reference, the claim is not patentable if the differences between the subject matter in the prior art and the subject matter in the claim would have been obvious to a person having ordinary skill in the art at the time of the invention.

30. Petitioners' counsel has informed me that a determination of whether a claim would have been obvious should be based upon several factors, including, among others:

- the level of ordinary skill in the art at the time the application was filed;
- the scope and content of the prior art; and
- what differences, if any, existed between the claimed invention and the prior art.

31. Petitioners' counsel has informed me that a single reference can render a patent claim obvious if any differences between that reference and the claims would have been obvious to a person having ordinary skill in the art. Alternatively, I understand that the teachings of two or more references may be combined in the

same way as disclosed in the claims, if such a combination would have been obvious to one having ordinary skill in the art. In determining whether a combination based on either a single reference or multiple references would have been obvious, it is appropriate to consider, among other factors:

- whether the teachings of the prior art references disclose known concepts combined in familiar ways, and when combined, would yield predictable results;
- whether a person having ordinary skill in the art could implement a predictable variation, and would see the benefit of doing so;
- whether the claimed elements represent one of a limited number of known design choices, and would have a reasonable expectation of success by those skilled in the art;
- whether a person having ordinary skill would have recognized a reason to combine known elements in the manner described in the claim;
- whether there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; and
- whether the innovation applies a known technique that had been used to improve a similar device or method in a similar way.

32. Petitioners' counsel has informed me that one of ordinary skill in the art has ordinary creativity and is not an automaton. Petitioners' counsel has also

informed me that in considering obviousness, obviousness may not be determined using the benefit of hindsight, including hindsight derived from the patent being considered.

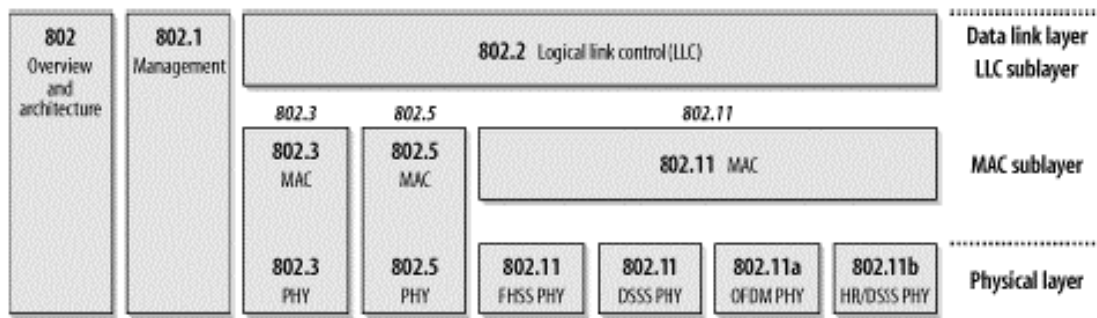
VI. TECHNICAL BACKGROUND

33. In the late 1990s and early 2000s, several technologies were targeted for data transmission, including networks based on the IEEE 802.11 standard which I refer to herein as “802.11 networks.” *See* Gast, at 5-10. I discuss 802.11 networks generally below.

A. Wireless Networks

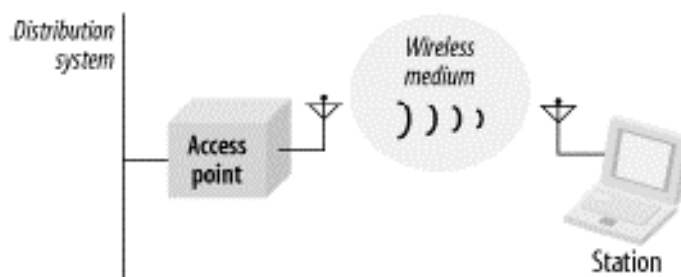
34. By the earliest possible priority date of the ’376 patent (November 2002), “802.11 [had] been adopted at a stunning rate.” Gast, at 162. 802.11 is part of the IEEE 802 family of specifications for local area network (LAN) technologies. *See* Gast, at 12; Figure 2-1 (below). The 802 specifications focus on the two lowest layers of the OSI protocol stack, the data link layer and physical layer. *Id.*, at 12. The MAC component of 802.11 “is a set of rules to determine how to access the medium and send data.” *Id.* The Physical layer (PHY) provides details of

transmission and reception of the data. *Id.* 802.11 uses radio waves as the physical layer. *Id.*, at 13.



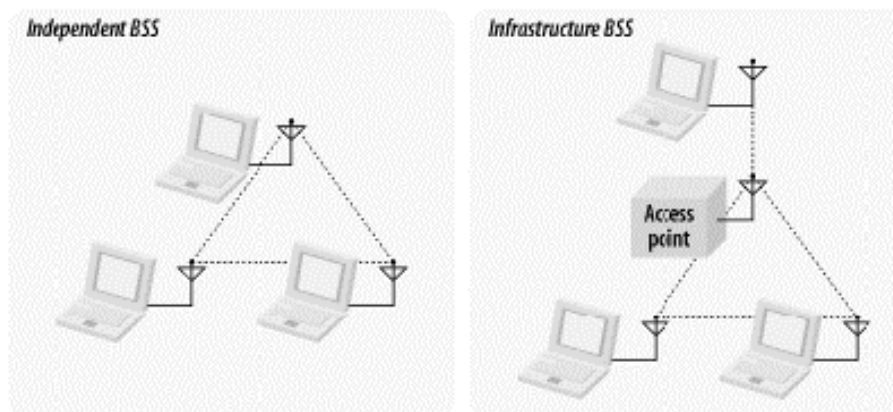
Gast Fig. 2-1

35. 802.11 networks consist of “four major physical components,” illustrated in Gast Figure 2-3 (reproduced below). “Frames on an 802.11 network must be converted to another type of frame for delivery to the rest of the world.” Gast, at 14. Access points perform the wireless-to-wired bridging function. 802.11 stations are simply computing devices with wireless network interfaces. *Id.* As I mentioned above, the 802.11 architecture uses a wireless medium to transmit 802.11 frames between access point and station (and vice versa). “When several access points are connected to form a large coverage area, they must communicate with each other to track the movements of mobile stations.” *Id.*, at 13. The distribution system forwards frames to their destination. *Id.*, at 13-14.



Gast, Fig. 2-3

36. In 802.11, communications take place in an area referred to as the “basic service area.” Gast, at 10. The group of devices (stations and access point) that communication with one another is referred to as the “basic service set (BSS).” *Id.* BSSs can be either independent networks or infrastructure networks, as illustrated in Figure 2-4 from Gast. I focus my discussion in this declaration on Infrastructure networks.



Gast, Fig. 2-4

37. An infrastructure BSS uses an access point for all communications, including communication between mobile nodes in the same service area. Gast, at

15. For example, an originating mobile station transfers a frame to the access point which transfers the frame to the destination station. *Id.* The base service area of an infrastructure network “is defined by the points in which transmissions from the access point can be received.” *Id.* Antennas therefore are of great interest and importance in 802.11 networks.

B. Antennas

38. Antennas are used at the end of the wireless link in every wireless system. An antenna “is a means of coupling radio frequency power from a transmission line into free space, allowing a transmitter to radiate, and a receiver to capture incident electromagnetic power.” *Liberti*, at 9.

39. Antennas can be designed with a directional preference. *Gast*, at 163. An omnidirectional antenna emits/radiates equally in all directions allowing the antenna to send and receive signals from any direction. *Id.* A directional or directive antenna focuses radiation in a preferred direction. A directional antenna “can reach farther with a clearer signal” and has “higher sensitivity to radio signals in the dominant direction.” *Id.*

40. A radiation pattern (also referred to as an antenna parameter) “is a graphical representation of the radiation (far-field) properties of an antenna.” *Stutzman*, at 33. A typical antenna pattern is shown as a polar plot of linear units (rather than decibels). *Id.* at 44. The **main lobe** (or main beam or major lobe) “is

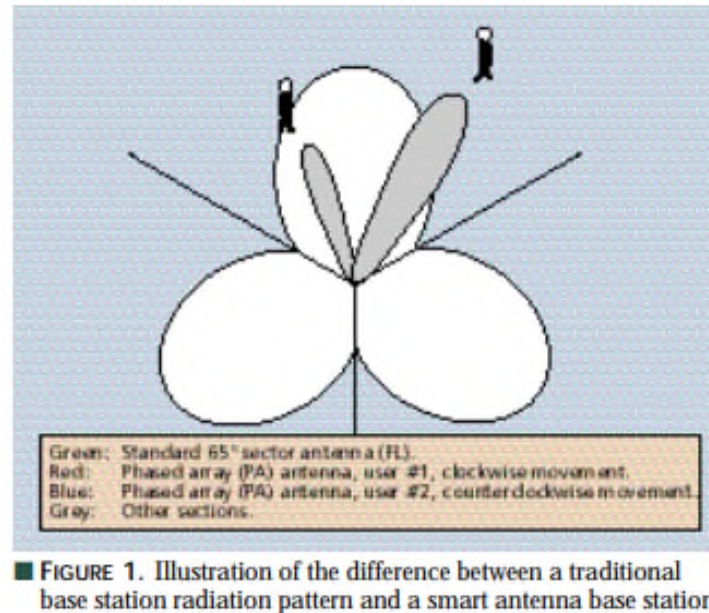
the lobe containing the direction of maximum radiation.” *Id.* An antenna pattern also includes “a series of lobes smaller than the main lobe”, referred to as side lobes or **minor lobes**. *Id.* A **side lobe** is “a radiation lobe in any direction other than that of the intended lobe.” *Id.* A **null** is the direction in which the pattern assumes very small values, ideally zero.

41. One important description of an antenna is its directivity—“how much it concentrates energy in one direction in preference to radiation in other directions.” Stutzman, at 46. Directivity is equal to an antenna’s power gain “if the antenna is 100% efficient.” *Id.*

C. Smart/Adaptive Antennas

42. By 1999, the rapid increase in the number of wireless users combined with new high bit rate data services being introduced by carriers was projected to result in a dramatic increase in traffic. Lehne, at 1. This projected increase “will put a demand on both manufacturers and operators to provide enough capacity in the networks.” *Id.* One technique to increase capacity in wireless systems is through the use of smart or adaptive antennas. *Id.* In early generations of wireless networks, base station antennas were omnidirectional or sectored. This approach was regarded as a waste of power because most of the power is “radiated in other directions than toward the user” as illustrated in Lehne Figure 1, below. *Id.* at 2. Smart antennas,

in contrast, use “antenna patterns that are not fixed, but adapt to the current radio conditions.” *Id.*



Lehne, Fig. 1

43. In general, “smart antennas direct their main beam, with increased gain, in the direction of the user, (they may direct nulls in the direction of the interfering signal as well).” Bhohe, at 2. The main philosophy behind smart antennas “is that interferers rarely have the same geographical location as the user.” Lehne, at 2. “By maximizing the antenna gain in the desired direction and simultaneously placing minimal radiation pattern in the directions of the interferers, the quality of communication link can be significantly improved.” *Id.* In mobile communications, “interferers are other users than the user being addressed.” *Id.*

44. An “adaptive antenna”, illustrated in Figure 1-7(b) below, is an “array of antennas which is able to change its antenna pattern dynamically to adjust to noise, interference, and multipath.” *Liberti*, at 7. Adaptive antennas “are used to enhance received signals and may also be used to form beams for transmission.” *Id.*, at 7. Switched beam systems “use a number of fixed beams at an antenna site” and the “receiver selects the beam that provides the greatest signal enhancement and interference reduction.” *Id.*, at 8. Smart antenna systems “can include both adaptive antenna and switched beam technologies.” *Id.*

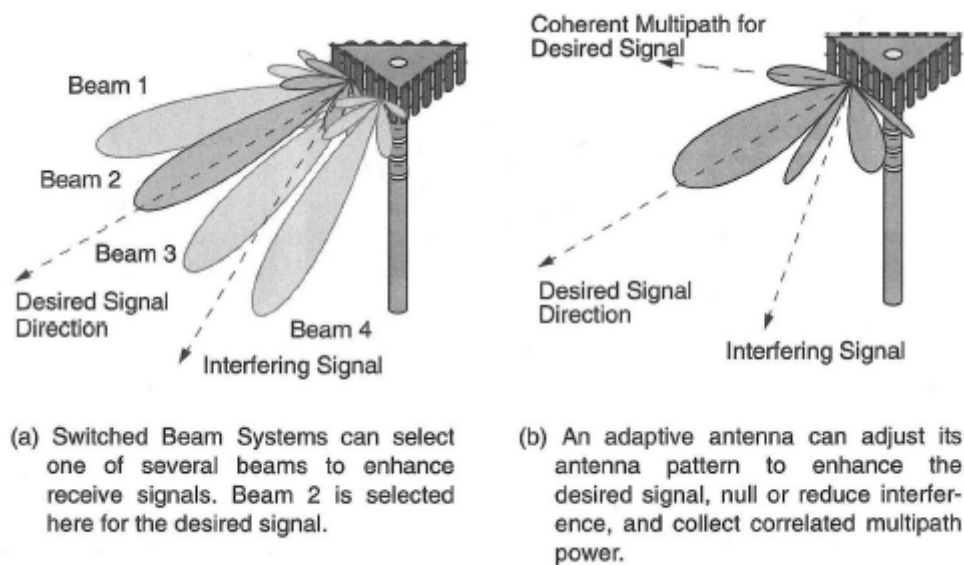
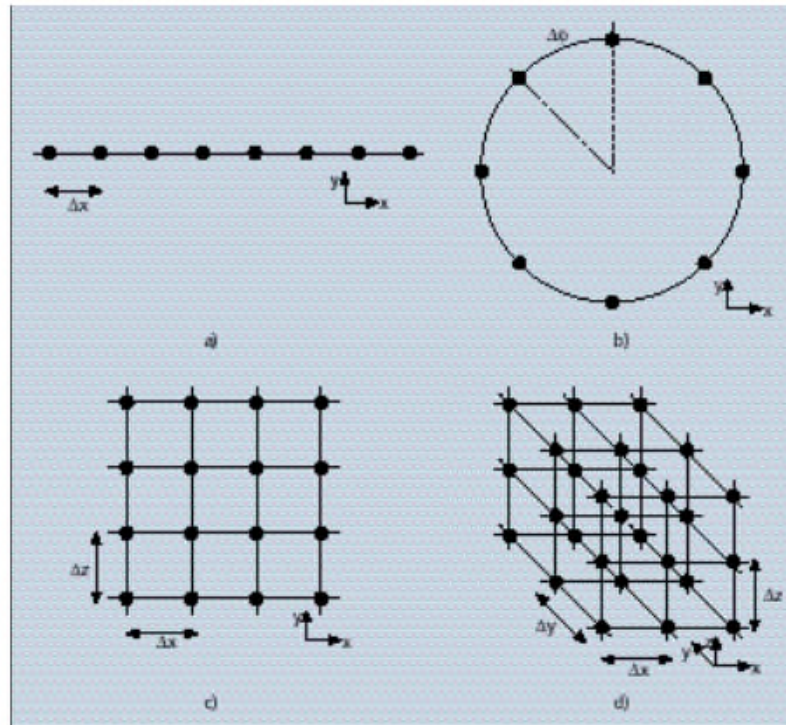


Figure 1-7 Two smart antenna technologies.

Liberti, Fig. 1-7

45. Steerable antenna patterns “are most often generated using array antennas” which consist of “a number of antenna elements on which the signal is divided or combined in both phase and amplitude.” *Lehne*, at 5. Antenna arrays

“can be one-, two- and three-dimensional, depending on the dimension of the space one wants to access.” *Id.* at 5-6. Figure 13 of Lehne, reproduced below, illustrates several exemplary array geometries.



■ FIGURE 13. Different array geometries for smart antennas: a) uniform linear array; b) circular array; c) 2 dimensional grid array; d) 3 dimensionanl grid array.

Lehne, Fig. 13

46. Beamforming “relates to the function performed by a device or apparatus in which energy radiated by an aperture antenna is focused along a specific direction in space.” Litva, at 34. “The objective is either to preferentially receive a signal from that direction or to preferentially transmit a signal in that direction.” *Id.* When transmitting, the main lobe of the antenna pattern is directed towards a certain direction using the phase and amplitude of each antenna element in an array.

47. Adaptive beamforming is the “procedure used for steering and modifying an array’s beam pattern in order to enhance the reception of a desired signal, while simultaneously suppressing interfering signals through complex weight selection.” *Id.*, at 48.

D. Spatial Multiplexing

48. In traditional cellular networks prior to 2002, “users communicating via the same base station have been separated by frequency, as in FDMA (frequency division multiple access); by time, as in TDMA (time division multiple access); or by code, as in CDMA (code division multiple access).” Lehne, at 2. Smart antennas enable a “new way of separating users, namely by space, through SDMA (space division multiple access).” *Id.* SDMA is “an adaptive array approach, and is realized as a combination of antennas (antenna arrays), analog radio frequency (RF) and digital electronics, and estimation and detection algorithms[, and] Resource allocation algorithms to effect efficient use of system resources.” Roy, at 4. Figure 1 of Roy (reproduced below) illustrates a typical intelligent antenna system configuration.

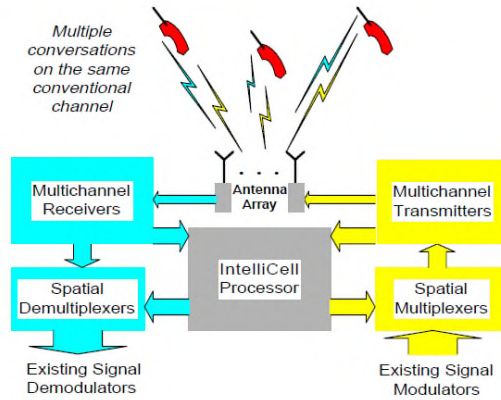


Figure 1: Typical Intelligent Antenna System Configuration

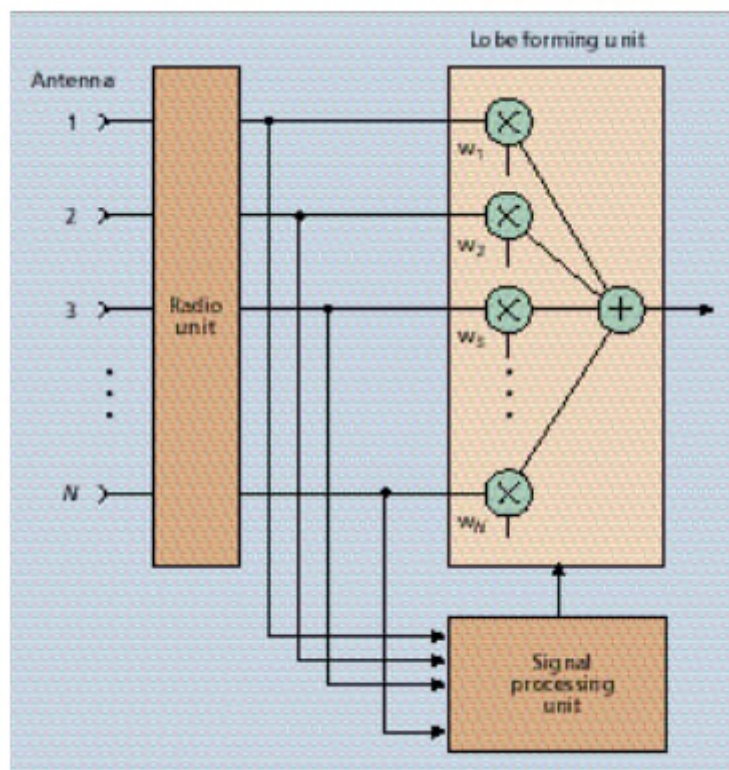
Roy, Fig. 1

49. The goal of SDMA “is slightly different in the uplink and the downlink.” Gerlach 1993, at 1. In receive beamforming, “the object is to separate several cochannel signals which are simultaneously impinging on the array, by forming separate beams for each incoming signal.” *Id.* “In transmit beamforming, the object is to simultaneously transmit several signals so that each signal is received only by its intended mobile.” *Id.*

1. Receive Beamforming

50. Figure 12 of Lehne (reproduced below) illustrates an exemplary reception part of a smart antenna. In this example, the antenna array contains N elements. Lehne, at 7. The N signals received from the N elements are combined into one signal “which is the input to the rest of the receiver (channel decoding, etc.)” *Id.* The radio unit includes down-conversion chains (one for each array

element) and analog-to-digital conversion (A/D). *Id.*, at 8. For the N received digital signals after down conversion and A/D, the signal processing unit calculates the complex weights with which the received signal from each of the array elements is multiplied. *Id.* The weights determine the antenna pattern in the uplink. The weights can be optimized from two main types of criteria: maximization of received signal power or maximization of the SIR (signal to interference ratio) from the desired user by suppressing signals from interference sources (adaptive array). *Id.* “In theory, with M antenna elements one can ‘null out’ M – 1 interference sources, but due to multipath propagation this number will normally be lower.” *Id.* The actual weighting of the received signal from each of the array elements is performed in the lobe forming unit. *Id.*, at 9.



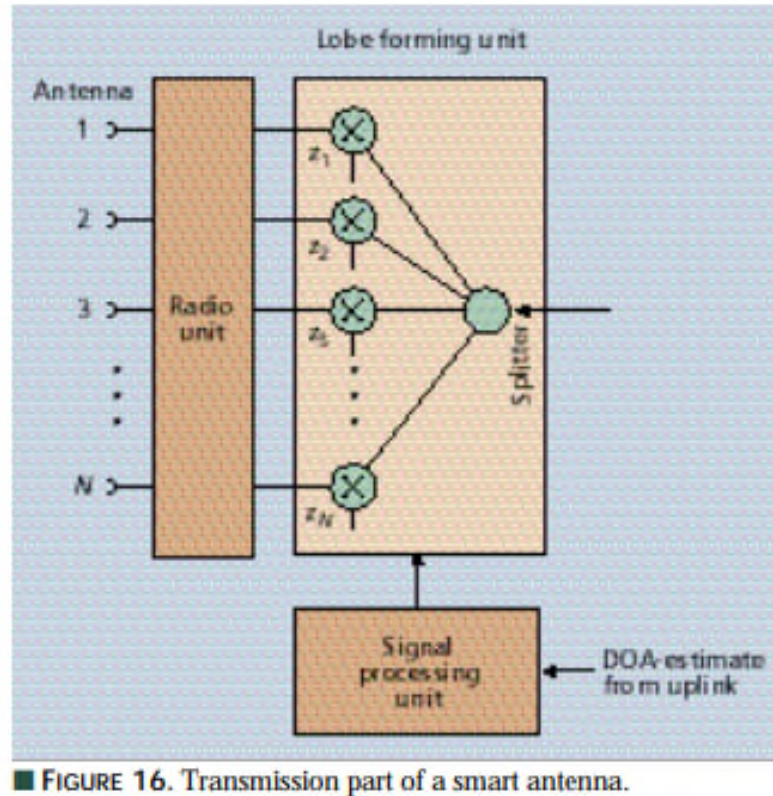
■ FIGURE 12. Reception part of a smart antenna.

Lehne, Fig. 12

2. Transmit Beamforming

51. Beamforming for the downlink steers the direction of beams towards receiving users using the transmission part of a smart antenna, which is “schematically very similar to the reception part.” Lehne, at 9. Figure 16 of Lehne, reproduced below, illustrates an exemplary transmission portion of a smart antenna. As shown in Figure 16, a signal to be transmitted “is split into N branches, which are weighted by the complex weights” at the baseband before the radio unit. *Id.* “The weights, which decide the radiation pattern in the downlink direction, are calculated by the signal processing unit.” *Id.* It is also possible “to position zeros in the

direction toward other users so that the interference suffered by these users is minimized.” *Id.*



Lehne, Fig. 16

52. Gerlach 1993 discusses an example of transmit beamforming. In this example, assume that both the number of receivers and number of transmitted information signals are equal to “d” and the number of antenna elements is equal to “m.” Gerlach 1993 assumes that there is “one information signal intended for each receiver” and therefore the d information signals are denoted as:

$$s_1(t), \dots, s_d(t)$$

Gerlach 1993, at 2. Each of these information signals sent by the base “is multiplied by its own vector which gives its complex amplitude weighting on the antenna elements.” *Id.* “The information signals are transmitted simultaneously, each according to its own complex weight vector.” *Id.*

53. The complex weights of the d signals across the m antenna elements “are summarized by the $m \times d$ matrix $\mathbf{W}_I$.” *Id.*, at 2 (emphasis in original). “The i^{th} column of $\mathbf{W}_I$ is the vector of weights according to which the i^{th} information signal is applied to the array.” *Id.* (emphasis in original). The radio channel from the antenna array elements to the mobile devices is characterized by a channel gain matrix $\mathbf{A}$ also of size $m \times d$, each of the $m \times d$ elements being a complex value *Id.* (emphasis in original). The channel matrix $\mathbf{A}$ “summarizes the entire propagation environment, which may include scattering and fading processes.” *Id.* (emphasis in original). Gerlach points out, however, that the channel matrix $\mathbf{A}$ “is normally unknown to the base, and since it is determined by the scattering and mobile locations, it is not under the control of the base.” *Id.*

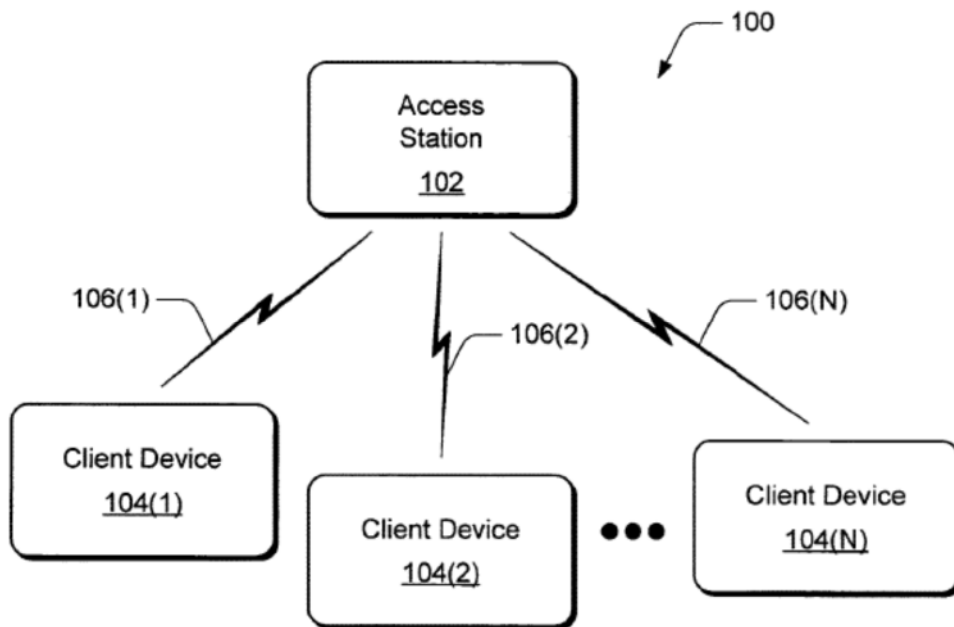
54. The transmitter selects weights $\mathbf{W}_I$ “so that each signal is only received by its intended user.” *Id.* Beampatterns which induce this condition are ‘complementary null beampatterns.’” *Id.* Since, as Gerlach points out, the channel matrix $\mathbf{A}$ is normally unknown to the base, a technique is needed to estimate channel matrix and provide a basis for choosing the transmit beamforming weights in the m

$\times d$ matrix $\mathbf{W}_I$. That is, “the desired signal at the mobile should have unity amplitude, and the remaining signals should have zero amplitude.” *Id.*, at 4.

55. One technique for estimating the channel matrix for downlink beamforming is a feedback technique such as described by Gerlach and Paulraj. Litva, at 195. In this technique, “the basestation transmits probing signals at the downlink frequency.” *Id.* “During the probing, normal information transmission is temporarily halted.” *Id.* “Each mobile in the cell measures its own responses to the probing signals and reports them back to the basestation.” *Id.* Using these responses, “the downlink channel transfer function is estimated for deriving the downlink weights.” *Id.*

VII. OVERVIEW OF THE '376 PATENT

56. The '376 patent relates to “a multi-beam directed signal system [] implemented to communicate over a wireless communication link via an antenna assembly with client devices” '376 patent, 3:11-15. This directed wireless communication system includes an access station and client devices, as illustrated in Figure 1 below.



'376 patent, Fig. 1

57. The patent states that the system “generates a directed wireless communication for transmission to wireless client device 202 via directed communication beam 214(1). This is in contrast to conventional omni-directional transmission systems that transmit a communication in all directions from an omni-directional antenna.” *Id.*, 5:31-35.

58. The system, illustrated in Figure 2 below, includes an access station 102 having a multi-beam directed signal transmission system 206 that “generates a directed wireless communication for transmission to wireless client device 202 via directed communication beam 214(1).” *Id.*, 5:26-29. The access station uses a processor, transceiver, or smart antenna assembly that produces a transmission

pattern that “selectively places transmission nulls and/or peaks within an applicable coverage area” to “emanate multiple directed communication beams” at client devices. *Id.*, 4:54-58, 5:5-9, and 5:59-67. “The antenna assembly can be implemented as two or more antennas, and optionally as a phased array of antenna elements.” *Id.*, 4:54-56.

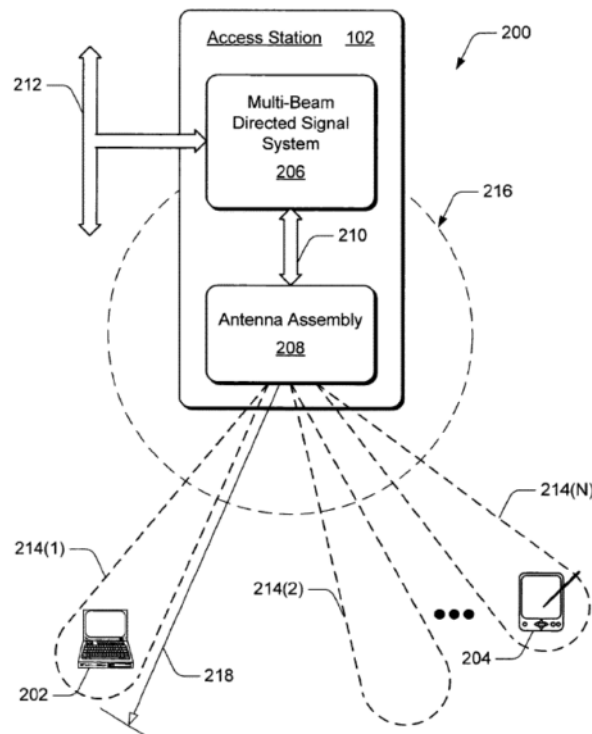


Fig. 2

'376 patent, Fig. 2

59. The access station can be implemented as “a nexus point, a trunking radio, a base station, a Wi-Fi switch, an access point, [or] some combination and/or derivative thereof.” *Id.*, 4:27-30. Client devices can include “portable computers,

computing devices, and any other type of electronic and/or communication device that can be configured for wireless communication.” *Id.*, 3:15-20.

60. The access station includes a smart antenna assembly that produces a transmission (beam) pattern that “selectively places transmission nulls and/or peaks within an applicable coverage area” to “emanate multiple directed communication beams” at client devices. *Id.*, 4:54-58, 5:5-9, and 5:59-67. “The antenna assembly can be implemented as two or more antennas, and optionally as a phased array of antenna elements.” *Id.*, 4:54-56.

61. A transmission peak “occurs in the transmission pattern 300 when a generated and particular amount of energy is directed in a particular direction.” *Id.*, 6:1-4. “Conversely, a transmission null (e.g., not a communication beam) occurs in the transmission pattern when no transmission of energy occurs in a particular direction, or a relatively insignificant amount of energy is transmitted in a particular direction.” *Id.*, 6:10-14.

VIII. OVERVIEW OF THE PRIOR ART

A. Gerlach

62. Gerlach is generally directed to “methods for transmitting signals from an antenna array to multiple receivers” using “feedback from the receivers” to minimize crosstalk. Gerlach, 1:6-9.

63. Gerlach teaches that “[w]ireless communication systems may use spatial multiplexing techniques wherein a single transmitter simultaneously emits multiple information signals, each of which is intended for one of a number of spatially separated receivers.” Gerlach, 1:13-17. Gerlach’s “conventional wireless communication system (30)” includes “a transmitting array (12) with transmitting elements (14) and multiple receivers (16).” Gerlach, 2:11-14. This is shown in Gerlach’s Fig. 1, reproduced below:

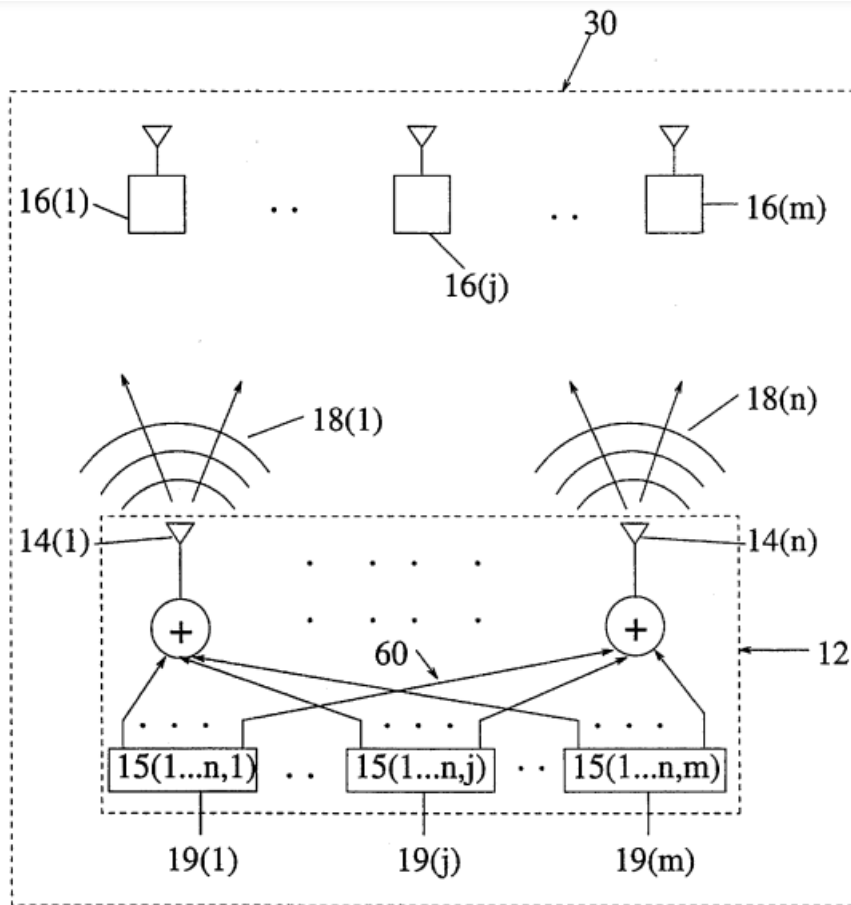


Fig.1

Gerlach, Fig. 1

64. In this conventional system, “[r]eceivers 16 are located in distinct directions with respect to transmitting array 12, and their angular separation provides a way to multiplex information signals 19.” Gerlach, 2:53-55. This type of multiplexing is referred to as “spatial multiplexing”; and, when applied to separate simultaneously transmitted signals in a multi-user system such as Gerlach, it is referred to as “Spatial Division Multiple Access” or SDMA. See Gerlach 1993, at 1.

65. As shown in in Fig. 1 above, “[i]nformation signals 19(1), 19(2) ... 19(m) excite transmitting elements 14(1)-14(n) collectively, giving rise to transmission signals 18 which are detected by receivers 16(1)-16(m), respectively.” Gerlach, 2:47-50. The information signals 19(1)-19(m) are applied “to elements 14(1)-14(n) with selected complex amplitudes 15(1,1), 15(1,2) ... 15(n-1,m) through connections 60.” Gerlach, 2:62-67. The complex amplitudes 15 “form the elements of a $n \times m$ weight matrix W .” Gerlach, 2:67-3:1 (emphasis added). The “[i]nteraction among resulting signals 18(1)-18(n) directs information signals 19 to their intended receivers 16.” Gerlach, 3:1-3. This “interaction among signals” is commonly referred to as the antenna’s radiation pattern or “beampattern.”

66. One problem with conventional systems that Gerlach identifies is “cross-talk.” Cross-talk is undesirable in wireless systems because it “degrades the quality of the signal at its intended receiver, and in the worst case, may wash it out

altogether.” Gerlach, 1:42-44. In the conventional SDMA system described by Gerlach, because the weight matrix W applied to transmitted signals was not optimized to reflect the locations of receivers 16 and the propagation environment through which the information signals 19 are transmitted, there is cross-talk at the receivers from the simultaneously transmitted signals. Gerlach’s Fig. 2a shows a beam pattern for an information signal in a SDMA wireless system without a mechanism to optimize weight matrix W to minimize cross-talk. In Fig. 2a, a “primary lobe 23(j) at angle γ is directed toward receiver 16(j) also at angle γ with respect to array 12, and side lobes 22(j) appear at a series of other angles.” Gerlach, 3:22-25. Because a receiver senses any signal which has a non-zero gain in its direction, the “receiver 16(l) at angle δ detects the non-zero amplitude of side lobe 22(j) at angle δ .” Gerlach, 3:25-28. That is, receiver 16(l) “detects signal 19(j) through side lobe 22(j), leading to cross-talk.” Gerlach, 3:28-29.

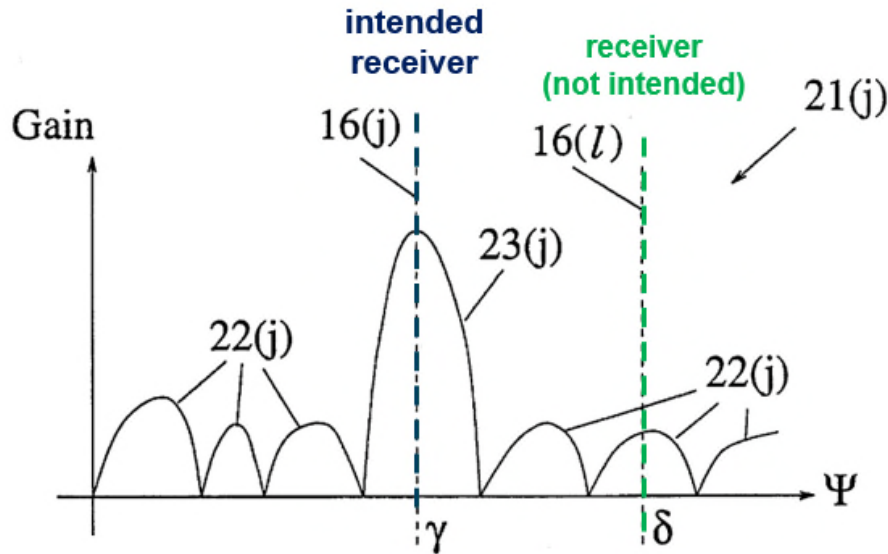


Fig. 2a

Gerlach, Fig. 2a (annotated)

67. To minimize cross-talk, Gerlach discloses a “wireless communications system” with an “adaptive transmitting antenna array” that uses “probing and feedback” signals between transmitter and receiver “to measure” a property of the channel. This information is combined to generate “beamforming weights” W' to allow for directing subsequent data transmissions to thereby reduce crosstalk.

68. Specifically, Gerlach discloses using “feedback signals 32 to adjust the amplitudes and phases 15 with which signals 19 are applied to transmitting elements 14.” Gerlach, 3:30-33. Feedback signals 32 “originate at receivers 16 in response to probing signals 17 applied to transmitting elements 14.” Gerlach, 3:43-46. Probing signals 17 are “transmitted with a selected weight matrix W , and the resulting feedback (32) [are] used to determine the transfer functions a_{kj} for each array-

element/receiver pair.” Gerlach, 1:57-60; Fig. 3a (below). Using a probing weight matrix W , “each transmitting element 14 of array 12 is successively excited by a single probing signal 17.” Gerlach, 5:23-25.

69. Annotated Figure 3a below shows Gerlach’s application of probing signal 17(1) to the transmitting array 12.

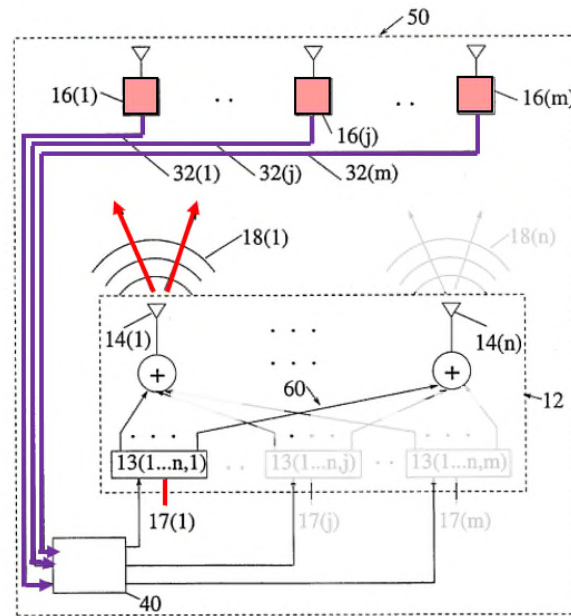


Fig. 3a

Gerlach, Figure 3a (annotated to show probing signal 17(1) and feedback signals 32)

70. A person having ordinary skill in the art would have understood that a non-zero weight is applied to the probing signal for element 14(1) and a zero weight is applied to the probing signal for every transmission element other than element 14(1). In particular, Gerlach teaches that “a probing weight matrix W with elements 13(1,1) ... 13(nm) having all components zero except for 1s in the diagonal position.”

Gerlach, 5:20-22. In other words, if there are $n=3$ elements and $m=3$ receivers, the probing weight matrix would look like:

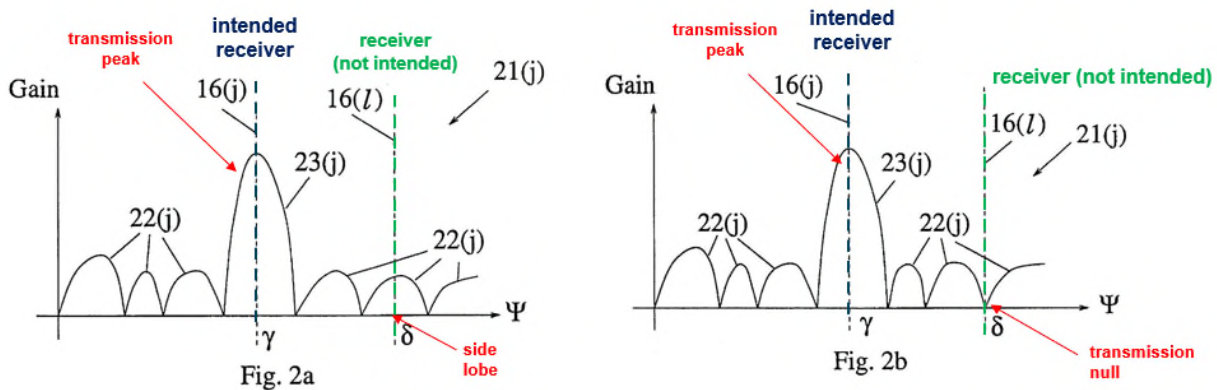
$$\begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

71. Thus (as in the first column), for probing signal 17(1) (intended for probing channel gains from 14(1) to each of the m receivers 16(1) ... 16(m)), a non-zero weight is applied between 13(1... n ,1) to 14(1) and a zero weight is applied to the probing signal between 13(1... n ,1) to every transmission element except element 14(1). Based on the probing signal 17(1), the m receivers 16(1), ..., 16(m) send feedback signals 32(1),..., 32(m), respectively (highlighted in purple above), which “are conveyed to weight computer 40 in array 12 for processing.” Gerlach, 3:46-48. This process is successively repeated for each element 14(i) of the antenna array, for $i=1, 2, 3, \dots n$ ($n=m$). For probing signal 17(i) (intended for probing channel gains from 14(i) to each of the m receivers 16(1)... 16(m)), a non-zero weight is applied between 13(1... n , i) to 14(i) and a zero weight is applied to the probing signal between 13(1... n , i) to every transmission element except element 14(i). Based on the probing signals 17(i), the m receivers 16(1), ..., 16(m) send the i -th feedback signals 32(1),..., 32(m), respectively, which “are conveyed to weight computer 40 in array 12 for processing.” Gerlach, 3:46-48.

73. Weight computer 40 processes the received feedback signals “by extracting information about the propagation environment from feedback signals 32” and the “[i]nformation conveyed by feedback signals 32 can then be used to determine” a new weight matrix, W' . Gerlach, 5:4-10.

39

12 thus “generate[s] a complimentary null beam pattern.” Gerlach, 5:7-10, 5:27-22. A complimentary null beampattern 21 has a “primary lobe 23(j) with unit gain at angle γ , in the direction of intended receiver 16(j), and side lobes 22(j) with nulls in the direction of all remaining receivers 16(l) where $l \neq j$ ” as illustrated in Fig. 2b (below right). Gerlach, 5:36-39.

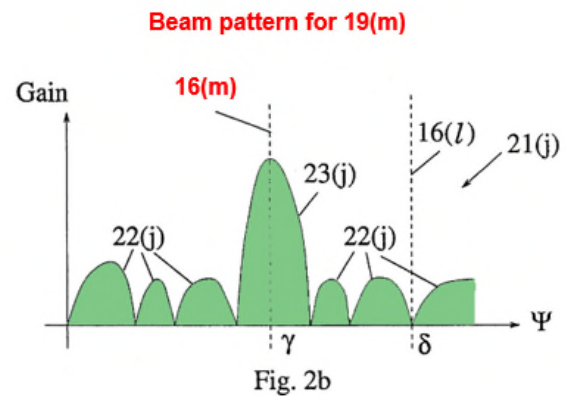
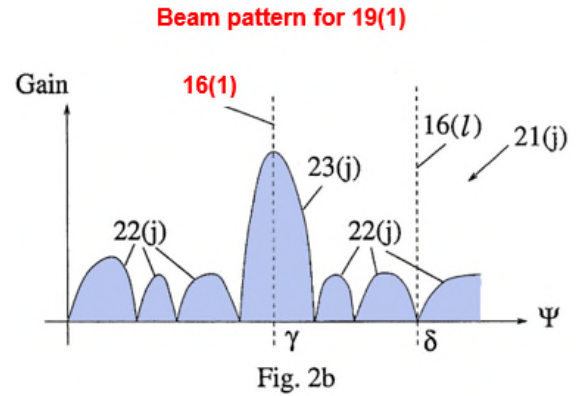
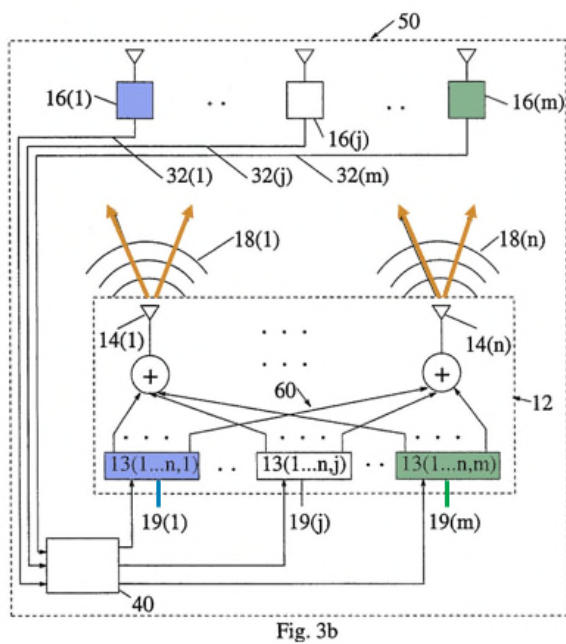


Gerlach, Figs. 2a, 2b (annotated)

75. As show by this side-by-side comparison, Gerlach’s probing/feedback technique places nulls in the direction of non-intended receivers, thereby eliminating (or rendering negligible) signal amplitude at the non-intended receivers. In other words, the generated null beampattern ideally has no cross talk. Gerlach, 5:9-10.

76. Gerlach’s probing/feedback technique is integrated with conventional multi-user spatial multiplexing of Gerlach’s Fig. 1 described above. For example, weight computer 40 and its associated processing is added to the conventional system.

77. In Gerlach's probing/feedback system, during signal transmission, information signal 19(1) is directed to receiver 16(1) (highlighted in blue in Fig. 3b below) and a different information signal 19(m) is now directed to receiver 16(m) (highlighted in green).



Gerlach, Figures 2b, 3b (annotated)

Weights for signal 19(1) are selected for the propagation environment between transmitting array 12 and receiver 16(1). In other words, the 1st column of weight matrix W' for receiver 16(1) is provided to transmitting array 12 (e.g., 15(1 ... n, 1)).

78. The weights for signal 19(i), i.e., the i^{th} column of weight matrix W' for receiver 16(i) is provided to transmitting array 12 (e.g., 13(1 ...n, i) are similarly selected for the propagation environment between transmitting array 12 and receiver 16(m). For example, the column of weight matrix W' for receiver 16(m) is provided to transmitting array 12 (e.g., 15(1 ...n, m). Information signal 19(1) is applied to elements 14(1)-14(n) with the selected weights highlighted in the blue box and information signal 19(m) is simultaneously applied to elements 14(1)-14(n) with the selected weights highlighted in the green box. The components of each weighted information signal are combined at an adder associated with each transmitting element 14 and the resulting signals are transmitted by transmission elements 14.

79. The interaction among the transmitted signals from each element 14 generates an antenna radiation pattern. Gerlach explains that “[e]ach information signal 19 will have its own beampattern 21 generated by interference between transmission signals 18.” Gerlach, 3:20-22. Annotated Figures 2b in paragraph 77 show “complimentary null beampattern” 21(1) directed to receiver 16(1) carrying information signal 19(1) (top right) and “complimentary null beampattern” 21(m) directed to receiver 16(m) carrying information signal 19(m) (bottom right).

B. Barratt

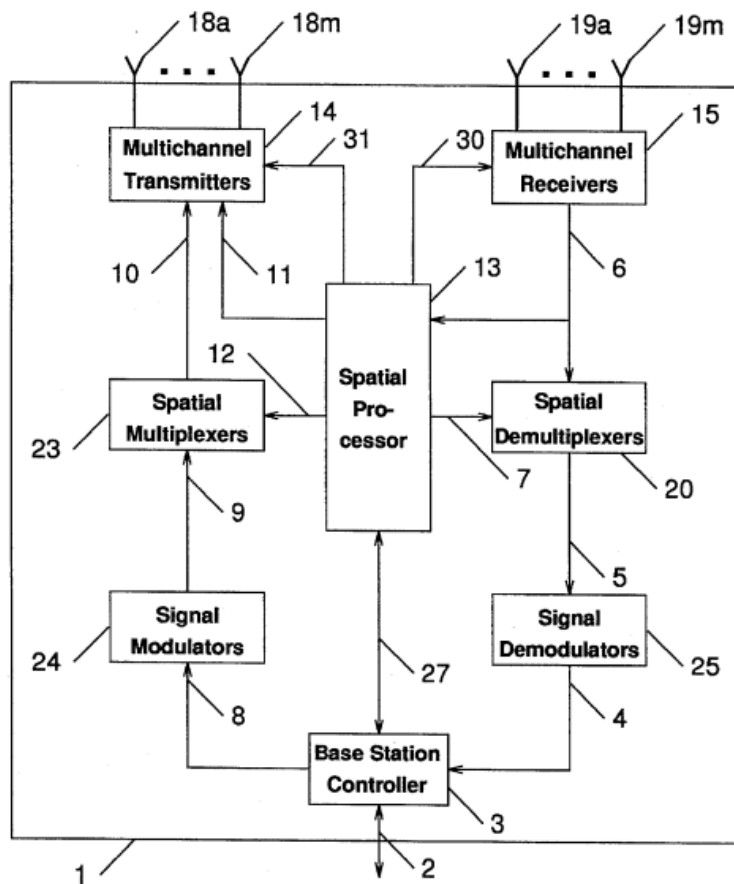
80. Barratt “relates to wireless communication systems and, more particularly, to using antenna arrays and signal processing to dramatically increase

the capacity and performance of wireless communication systems.” Barratt, 1:15-18. A wireless system includes “a network of base stations for receiving uplink signals transmitted from a plurality of remote terminals and for transmitting downlink signals to the plurality of remote terminals using a plurality of conventional channels.” Barratt, Abstract.

81. Barratt’s base station, illustrated in Fig. 1 below, includes, on the transmit side, signal modulators 24, spatial multiplexers 23, and multichannel transmitters coupled to transmitting antennas 18a-18n and, on the receive side, multichannel receivers 15 coupled to receive antennas 19a-19n, spatial demultiplexers 20, and signal demodulators 25. The base station also includes a base station controller 3 and spatial processor 13.

82. Base station controller 3 “acts as an interface between base station i and any external connection via a base station communication link 2, and serves to coordinate the overall operation of base station 1.” Barratt, 6:56-59. Spatial processor 13 “produces and maintains spatial signatures for each remote terminal for each conventional frequency channel, and calculates spatial multiplexing and demultiplexing weights for use by spatial demultiplexers 20 and spatial multiplexers 23.” Barratt, 7:60-64. In an embodiment of Barratt, “transmission antennas 18(a, ... , m) and reception antennas 19(a, ... , m) at base station 1 are replaced by a single array of m antennas.” Barratt, 20:30-32. Each antenna element in the array “is

attached to both its respective component of multichannel transmitters 14 and its respective component of multichannel receivers 15 by means of a duplexer.” Barratt, 20:32-35. A person having ordinary skill in the art would have been motivated to use this embodiment having a shared antenna array and duplexer to minimize the space and cost taken by the antenna arrays at a base station which is size constrained and to minimize overall base station cost.



Barratt, Fig. 1

83. For transmission, signal modulators 24 “produce modulated signals 9.” Barratt, 8:60-61. A set of spatial multiplexing weights 12 for each remote terminal

are then “applied to the respective modulated signals in spatial multiplexers 23 to produce spatially multiplexed signals to be transmitted 10 for each of the m transmit antennas 18(a, ..., m) and each of the N_{cc} conventional channels.” Barratt, 8:60-67. The “[m]odulated and spatially multiplexed signals 10 are inputs to a bank of m phase coherent multichannel transmitters 14.” Barratt, 9:49-50.

84. For reception, “[i]ncoming or uplink radio transmissions impinge on an antenna array composed of a number, m , of receive antenna elements 19(a, ... , m) each of whose outputs is connected to one of m multichannel receivers in a bank of phase-coherent multichannel receivers 15.” Barratt, 6:63-67. The multichannel receivers “produce received signal measurements 6 which are supplied to spatial processor 13 and to a set of spatial demultiplexers 20.” Barratt, 7:53-58. The “outputs of spatial demultiplexers 20 are spatially separated uplink signals 5 for each remote terminal communicating with the base station.” Barratt, 8:36-38. Spatially separated uplink signals 5 are then “demodulated by signal demodulators 25, producing demodulated received signals 4.” Barratt, 8:38-42.

85. Barratt further teaches using “predetermined calibration signals 11” for determination of the transmit and receive spatial signatures of the remote terminals. Barratt, 10:10-13. The base station uses the spatial signatures “to determine which conventional communication channel the remote terminal should use.” Barratt, 12:8-13. Specifically, a spatial signature processor 38 in the base station “commands the

remote terminal to enter calibration mode by transmitting a command to it on the downlink channel.” Barratt, 16:44-50. The base station then “transmits predetermined calibration signals 11, on the conventional channel occupied by the remote terminal.” Barratt, 16:50-55. The remote terminal then “transmits back the signal received at the remote terminal.” Barratt, 16:60-61. The “spatial signature processor 38 computes the receive and transmit spatial signatures of the remote terminal from the received signal measurements 6 and predetermined calibration signals 11.” Barratt, 16:64-17:2. To a person having ordinary skill in the art, Barratt’s “predetermined calibration signals 11” serve as probing signals between the base station and the remote terminal.

C. Okamoto

86. Okamoto describes a “Smart Wireless LAN (SWL) system” that “integrates the Space-Division Multiple-Access (SDMA) technique with the IEEE 802.11 wireless standard.” Okamoto, at 1. Okamoto explains that “[c]ertain features of the 802.11 specifications aid the implementation of an SDMA system.” Okamoto, at 2. In particular, Okamoto teaches that “[t]iming considerations, critical for SDMA, are aided by 802.11 specifications such as the regularly broadcast frame by the base station which synchronizes the clocks of all terminals in its local area.” *Id.* Okamoto further teaches that “[o]ther features in 802.11 that aid SDMA systems are

power control, the frame structure with contention and contention free periods, and terminal identification fields in each header.” *Id.*

87. The base station relies on structure that “was created to be 802.11 compatible while allowing for the use of SDMA.” Okamoto, at 2. By implementing SDMA, Okamoto’s SWL “achieve[s] through-put multiplication by exploiting the rich spatial diversity existing among spatially separate users” on a network. Okamoto, at 1.

IX. CLAIM CONSTRUCTION

88. I have given all the claim terms their plain and ordinary meaning, as would have been understood by a person having ordinary skill in the art, at the time of the alleged invention, which I am informed is early November 2002, having taken into consideration the language of the claims, the specification, and the prosecution history of record.

X. THE PRIOR ART DISCLOSES OR SUGGESTS ALL OF THE FEATURES OF THE CHALLENGED CLAIMS

A. Grounds Challenging Claims 1-34 of the ’376 patent.

89. I understand that the Petition is challenging claims 1-34 of the ’376 patent on 2 separate grounds.

90. I understand that the *first ground* is challenging claims 1-9, 12-18, and 22-34 of the ’376 patent as obvious over Gerlach in view of Barratt.

91. I further understand that the ***second ground*** is challenging claims 10-11 and 19-21 of the '376 patent as obvious over Gerlach in view of Barratt and in further view of Okamoto

92. Throughout this declaration, I cite to references *other* than Gerlach, Barratt, and Okamoto. To be clear, I rely on these references as evidence of a person having ordinary skill in the art's knowledge and the state of the art. However, these other references are not part of the unpatentability Grounds.

B. The Combination of Gerlach and Barratt Discloses or Suggests All of the Features of Claims 1-9, 12-18, and 22-34

1. A Person Having Ordinary Skill in the Art Would Have Been Motivated to Combine Gerlach with Barratt

93. In my opinion, a person having ordinary skill in the art would have been motivated to combine the basic base station architecture taught by Barratt with Gerlach's application of probing/feedback techniques to a conventional system to adjust the weight matrix used in a conventional wireless system using SDMA.

94. I would first note that, while Gerlach describes the general concept of a wireless communications system, it has a limited description of the implementation details of a wireless network-based apparatus. The specific implementation is left as a design choice to one who implements the system. Thus, without such a description, a person having ordinary skill in the art would have been motivated to find references that provide those details to develop an operational wireless system.

A person having ordinary skill in the art would have been able to look to Barratt which describes a network-based apparatus using spatial multiplexing but does not describe techniques for beamforming.

95. I would also note that Gerlach has limited description of the implementation details uplink signal reception in its network-based apparatus. Instead, understanding that a person having ordinary skill in the art would have been familiar with such implementation details and known methods at the time of its invention, Gerlach merely states that feedback signals 32 “originate at receivers 16 in response to probing signals 17” and are “conveyed to weight computer 40” of the wireless communication system. Gerlach, 3:43-47.

96. A person having ordinary skill in the art would have understood that some method of conveying the feedback signals back to the wireless system, i.e., an uplink channel, would be necessary in order to implement Gerlach’s system. Without such method, there would be no way for the feedback signals to get from the receivers 16 to weight computer 40, which are in different physical devices. A person having ordinary skill in the art would, thus, have been motivated to combine Barratt’s base station architecture teachings with Gerlach to provide techniques for receiving uplink signals in a system including feedback for multiple access, spatial multiplexing transmission.

97. Additionally, as discussed above in Section VIII.B, Barratt's duplexer allows for the use of a single antenna array for both receiving and transmitting. A person having ordinary skill in the art would have been motivated to combine Gerlach and Barratt to reduce cost and size of the network-based apparatus through the use of a shared antenna array and duplexer by avoiding the use of a second antenna array.

98. In my opinion, the combination of Gerlach and Barratt would have amounted to no more than combining elements in the prior art (Gerlach's feedback mechanism in an SDMA system and Barratt's based station components) according to known methods to yield predictable results.

99. It is also my opinion that a person having ordinary skill in the art would have also had a reasonable expectation of success in making the combination. More particularly, Gerlach's probing/feedback technique is a software-based process executing on Gerlach's weight computer. The processing performed by Gerlach's weight computer is similar to Barratt's spatial processing. Because Barratt describes how to transmit and receive spatially multiplexed signals using weight-controlled beampatterns, a POSITA would have been able to implement Gerlach's software-based technique which optimizes the beampatterns to support SDMA through the use of adjustable, optimized weights. Because the elements of the combined systems

perform the same basic functions, the results of the combination would have been predictable to a POSITA.

2. Claim 1

a. “A data-communications networking apparatus, comprising:”

100. I understand that “[a] data-communications networking apparatus, comprising” is the preamble to claim 1 of the ’376 patent. I have been asked to assume that the preamble is a claim limitation. Under that assumption, in my opinion, the combination of Gerlach and Barratt teaches “[a] data-communications networking apparatus.”

101. For example, Gerlach makes use of a “wireless communication system.” Gerlach, 2:39-41. Gerlach conceptually describes aspects of the communication system in Figs. 3a and 3b that are used in Gerlach’s probing/feedback techniques. For example, Gerlach’s system includes a transmitting array 12 comprising transmitting elements 14(1), 14(2), ... 14(n) and receivers 16(1), 16(2) ... 16(m). See Gerlach, 2:44-46. Transmitted signals 18(1) ... 18(n) “are generated at elements 14(1)-14(n), respectively, by applying information signals 19(1)-19(m) to elements 14(1)-14(n) with selected complex amplitudes

15(1,1), 15(1,2) ... 15(n-1,m), 15(n,m)² through connections 60.” Gerlach, 2:62-67, 3:51-56.

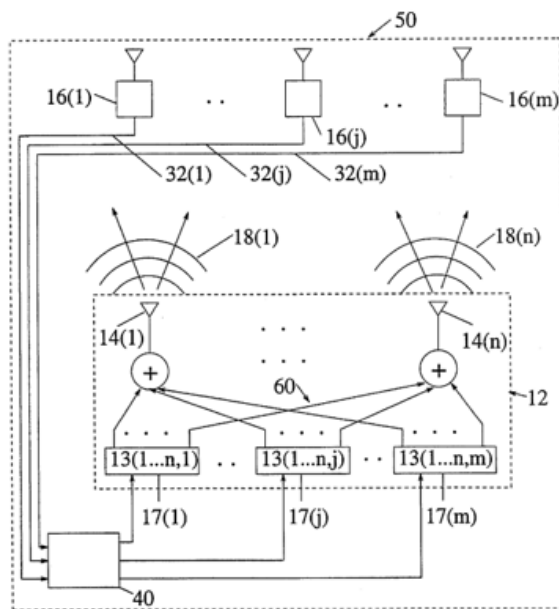


Fig. 3a

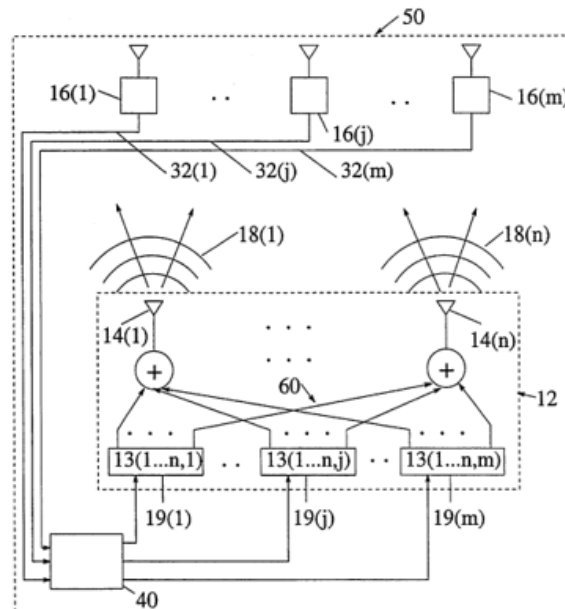


Fig. 3b

Gerlach, Figs. 3a, 3b

102. In my opinion, a person having ordinary skill in the art would have understood that transmitting array 12 and its associated weight computer 40, shown in Gerlach’s Figs. 3a and 3b above, are components of a network-based apparatus such as a base station or access point. Thus, Gerlach alone discloses or suggests a “data-communications network apparatus.”

² Complex amplitudes are identified as 15(1,1)-15(n,m) and 13(1,1)-13(n,m)

“merely to distinguish between information transmission and probing modes.”

Gerlach, 3:51-56.

103. Barratt, also, describes a “wireless system comprising a network of base stations for receiving uplink signals transmitted from a plurality of remote terminals and for transmitting downlink signals to the plurality of remote terminal.” Barratt, Abstract. A person having ordinary skill in the art would have understood that a base station is itself a “data-communication network apparatus.”

104. Thus, in my opinion, a person having ordinary skill in the art would have understood would have understood that the combination of Gerlach and Barratt discloses or suggests “[a] data-communications networking apparatus.”

b. “a processor configured to:”

105. In my opinion, the combination of Gerlach and Barratt discloses or suggests “a processor” configured as described in the limitations discussed in Sections X.B.2.b(i) and X.B.2.b(ii).

106. As I discuss in further detail below in Sections X.B.2.b(i) and X.B.2.b(ii), Gerlach describes generating “information signals 19 and probing signals 17,” which are “distributed among transmitting elements 14 according to complex amplitudes 15 (1,1)-15(n,m) and 13(1,1)-13(n,m), respectively,” and transmitted to receivers 16. Gerlach, 3:42-45, 3:49-54, Figs. 3a, 3b.

107. A person having ordinary skill in the art would have understood that one or more processors would be used to generate “information signals 19 and probing signals 17.” In an RF system, data (bits) to be transmitted must be converted

to a signal, such as a baseband signal (symbols) that can be used to modulate a carrier for transmission. Therefore, a person having ordinary skill in the art would have understood that probing signals 17 and information signals 19 provided as input to Gerlach's transmitting array 12 are baseband modulated signal symbols in order to multiple with the complex weights in 13 and 15, respectively. Gerlach, 3:51-56 ("In FIGS.3, information signals 19 and probing signals 17 are shown distributed among transmitting elements 14 according to complex amplitudes 15(1,1)-15(n,m) and 13(1,1)-13(n,m), respectively, merely to distinguish between information transmission and probing modes."). Before 2002, it was well-known to a person having ordinary skill in the art that that baseband modulation (i.e., bit to symbol mapping) techniques, including those used for wireless communication like quadrature amplitude modulation (QAM), were performed in software. *See, e.g.,* Wakutsu, ¶10 ("[I]n a software-defined radio terminal, a modulating/demodulating process operation and a coding system are processed using software, and the software-defined radio machine can transmit and receive radio signals within several different radio communication systems."); Ferris, ¶¶14, 325 (discussing the use of software for channel coding and modulation, including QAM); Dogan, 2:37-3:17 (discussing the use of constant modulus modulation algorithm); Paulraj, 27:60-64, 28:25-28 (encoder/modulator module may be implemented by either hardware or software). Moreover, processors capable of performing signal encoding and

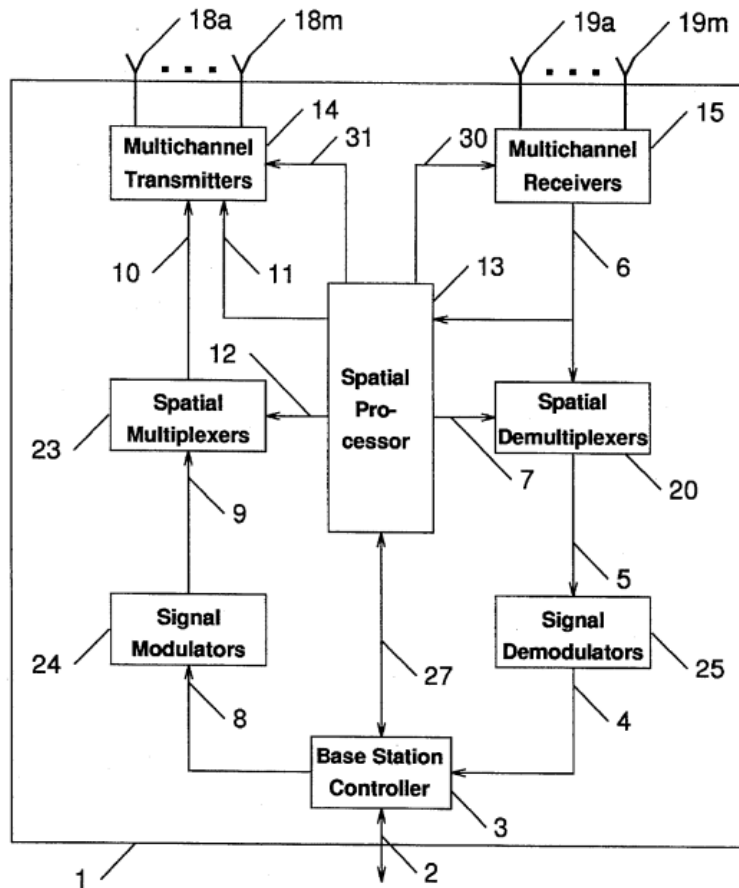
baseband modulation in wireless applications were widely available by 2002. *See, e.g.,* Menon, 11:27-33 (discussing that a baseband processor is capable of “formulating continuous phase modulated spread-spectrum signals, or other types of quadrature or related signals” as disclosed in the prior art). Qualcomm, at 1 (the Qualcomm MSM6000 baseband processor encoded and modulated CDMA2000 signals); Thomson, at 1 (discussing the capability of a baseband processor to format and send QAM modulated signals in a 802.11 system); Texas Instruments, at 1 (discussing the release of a 802.11b baseband processor providing modulation in accordance with the IEEE 802.11b standard).

108. Based on the knowledge of the art at the time, a person having ordinary skill in the art would have understood that Gerlach inherently teaches or at a minimum suggests a processor in the network-based apparatus for modulating a data signal onto a carrier to generate the modulated signal. Gerlach already discloses a weight computer 40 that “processes” received feedback signals, thus showing the usefulness of processors in the system. Gerlach, 3:45-47 (“Feedback signals 32 are conveyed to weight computer 40 in array 12 **for processing.**”). A person having ordinary skill in the art would have sought to use a processor—whether the same processor that implements the weight computer or one or more additional processors—to execute software instructions for generating modulating signals. Doing so would have obviated the need for developing special purpose hardware to

perform this processing and would have simplified the design and development of the communication system.

109. Accordingly, in my opinion, Gerlach inherently discloses or at least suggests a processor configured to perform the functionality of the limitations that follow.

110. Regardless of whether Gerlach discloses or suggests “*a processor*,” Barratt does so. For example, Barratt’s base station includes a “base station controller 3 [that] acts as an interface between base station i and any external connection via a base station communication link 2, and serves to coordinate the overall operation of base station 1.” Barratt, 6:55-59. The base station controller 3 is shown in Fig. 1 of Barratt reproduced below.



Barratt, Fig. 1

111. Barratt discloses that this base station controller 3 “is implemented with a conventional central processing unit and associated memory and programming.” Barratt, 6:59-62. The base station also includes “signal modulators 24 [that] produce modulated signals 9” and signal demodulators 25. Barratt, 8:60-67. For the reasons I discuss above, a person having ordinary skill in the art would have found it obvious to implement Barratt’s signal modulators 24 via software executed on a processor,

either using the same CPU as the base station controller or using one or more additional processors.

112. In my opinion, a person having ordinary skill in the art would have found it obvious to incorporate Barratt's modulators/processor(s) in Gerlach to generate the probing and first/second information signals for the reasons discussed in Section X.B.1.

113. In my opinion, therefore, the combination of Gerlach alone or in combination with Barratt teaches a processor configured to as discussed in Sections X.B.2.b(i) and X.B.2.b(ii).

(i) “generate a probing signal for transmission to at least a first client device and a second client device;”

114. In my opinion, the combination of Gerlach and Barratt discloses or suggests a processor configured to “generate a probing signal for transmission to at least a first client device and a second client device.”

115. Gerlach discloses that “each transmitting element 14 of array 12 is successively excited by a single probing signal 17” using a probing weight matrix W , which has all components zero except for 1s in the diagonal position.” Gerlach, 5:22-30.

116. In the annotated Fig. 3a below left, I show how element 14(1) is first excited by probing signal 17(1) and the remaining elements are not excited by

probing signal 17(1) in Gerlach's system because its associated weight is non-zero and the remaining elements are not excited by probing signal 17(1) because their associated weights are zero. Here, the antenna pattern is not directed to a single receiver. Rather, multiple receivers 16 in communication range of transmitting array 12 (highlighted in red) receive the transmitted probing signal (18(1)). Gerlach, 3:43-45 ("feedback signals 32 originate at receivers 16"). Each receiver 16 that receives the probing signal returns a feedback signal 32 to the wireless communication system. See Gerlach, 3:43-46 ("Feedback signals 32 originate at receivers 16 in response to probing signals 17 applied to transmitting elements 14, according to complex amplitudes 13.") For each element 14(i) of the antenna array this process is repeated. For example, in the annotated Figure 3a below right, I show the process for probing signal 17(m) and the final transmitting element 14(m) of the array (where $n=m$). Gerlach assumes a square matrix (having 1s in the $n=m$ diagonal positions), thus, a person having ordinary skill in the art would have understood that "m" can be assumed to be equal to "n" in Figure 3a.

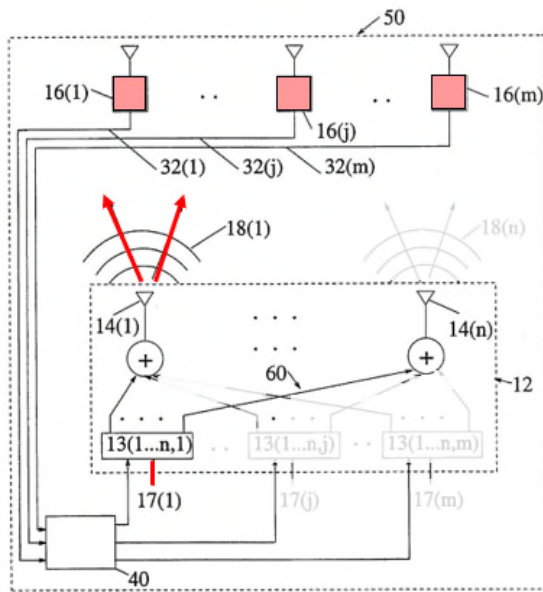


Fig. 3a

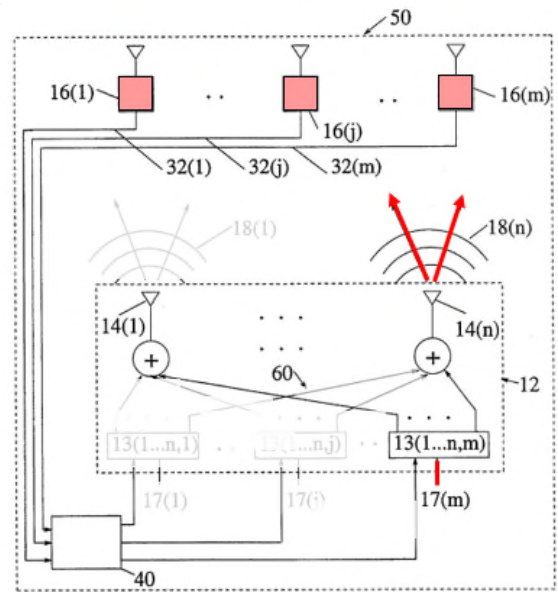


Fig. 3a

Gerlach, Figure 3a (annotated to show probing signal 17(1)) at left and probing signal 17(m) at right)

117. As discussed above in Section X.B.2.b, a person having ordinary skill in the art would have found it obvious to use a processor to generate probing signals (17). Thus, in my opinion, the combination of Gerlach and Barratt discloses or suggests a processor that generates probing signal 17 (“generate a probing signal”) for transmission to receivers 16(1) and 16(m) (“for transmission to at least a first client device and a second client device”).

(ii) “generate a first data stream for transmission to the first client device” and “generate a second data stream for transmission to the second client device”

118. In my opinion, the combination of Gerlach and Barratt discloses or suggests a processor configured to “generate a first data stream for transmission to the first client device” and to “generate a second data stream for transmission to the second client device.”

119. Gerlach explains that in an SDMA system, “a single transmitter simultaneously emits multiple information signals, each of which is intended for one of a number of spatially separated receivers.” Gerlach, 1:13-16. For example, in the conventional system shown in Gerlach’s Fig. 1, “[i]nformation signals 19(1), 19(2) ... 19(m) excite transmitting elements 14(1)-14(n) collectively, giving rise to transmission signals 18 which are detected by receivers 16(1)-16(m), respectively.” Gerlach, 2:47-50.

120. In particular, “transmitted signals 18(1) ... 18(n) are generated at elements 14(1)-14(n), respectively, by applying information signals 19(1)-19(m) to elements 14(1)-14(n) with selected complex amplitudes 15(1,1), 15(1,2) ... 15(n-1,m), 15(n,m) through connections 60.” Gerlach, 2:62-67. Thus, in a conventional SDMA system, a first data stream (information signal 19(l)) is generated for transmission to the first client device (receiver 16(l)).

121. This same conventional multi-user spatial multiplexing is used with Gerlach's probing and feedback technique which modifies the weights (complex amplitudes) applied to each information signal. For example, as shown in annotated Fig. 3b below,³ information signal 19(1) is directed to receiver 16(1) (highlighted in blue) and information signal 19(m) is directed to receiver 16(m) (highlighted in green). Weights for signal 19(1) are selected for the propagation environment between the transmitting array and receiver 16(1) and weights for signal 19(m) are selected for the propagation environment between the transmitting array and receiver 16(m). Information signal 19(1) is applied to elements 14(1)-14(n) with selected

³ I note that although Figure 3b illustrates a feedback embodiment using probing signals, a person having ordinary skill in the art would have understood that Gerlach's system illustrated in Fig. 3b also transmits information signals without feedback using weights 15 instead of weights 13. *See, e.g.*, Gerlach, 3:51-56 (discussing use of amplitudes 15 for information signals and amplitudes 13 for probing signals), 5:9-10 (discussing transmitting information signals using weight matrix, W').

weights $15(1\dots n,1)^4$ used in the highlighted blue box and information signal $19(m)$ is simultaneously applied to elements $14(1)-14(n)$ with selected weights $15(1\dots n,m)$ used in the highlighted green box. The components of each weighted information signal are combined at an adder associated with each transmitting element 14.

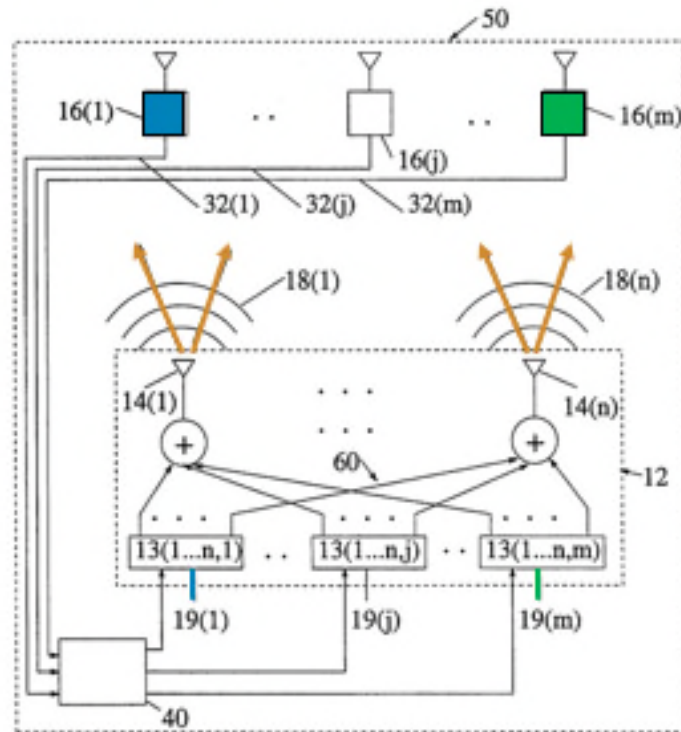
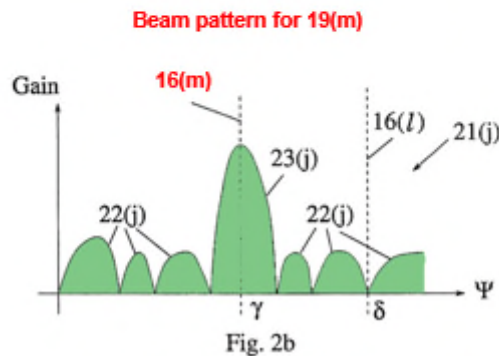
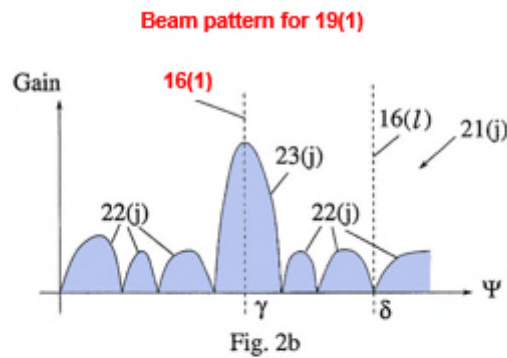


Fig. 3b

Gerlach, Fig. 3b (annotated)

⁴ I note that to a person having ordinary skill in the art at the time of Gerlach, the notation $15(1\dots n,i)$ indicates n weight elements arranged as the i -th column of a matrix representing the weight matrix W or W' . Gerlach's Fig.3b used this notation consistently.

122. The resulting transmitted signals from multiple elements 14(1), ..., 14(n) generate a beampattern directed to receiver 16(1) carrying information signal 19(1) with nulls directed to other receivers and a beam pattern directed to receiver 16(m) carrying information signal 19(m) with nulls directed to other receivers, as shown in the annotated copies of Fig. 2b below.



Gerlach, Figures 2b (annotated)

123. As discussed above in Section X.B.2.b, a person having ordinary skill in the art would have found it obvious to use a processor to generate information signals 19. Thus, in my opinion, the combination of Gerlach and Barratt discloses or suggests a processor that generates information signal 19(1) (“generate a first data

stream”) for transmission to receiver 16(l) (“for transmission to the first client device”), and information signal 19(m) (“generate a first data stream”) for transmission to receiver 16(m) (“for transmission to the second client device”).

c. “a transceiver operatively coupled to the processor and configured to:”

124. In my opinion, the combination of Gerlach and Barratt teaches “a transceiver operatively coupled to the processor” configured as described in the limitations discussed in Sections X.B.2.c(i) and X.B.2.c(ii). To a person having ordinary skill in the art, the plain meaning of a “transceiver” is simply a device that operates to both transmit and receive signals. I note that the specification of the ’376 patent does not use the term “transceiver” at all. Instead, the ’376 patent explains that “[t]he multi-beam directed signal system 206 can transmit and/or receive (i.e., **transceive**) information (e.g., in the form of data packets) by way of one or more directed communication beams 214 as a wireless communication via the antenna assembly 208.” ’376 patent, 5:5-9, 5:9-12 (“Additionally, wireless communication(s) are **transmitted and/or received from (i.e., transceived** with respect to) a remote client device, such as client devices 202 and 204.”). Thus, a person having ordinary skill in the art would have understood that the ’376 patent is discussing a “transceiver” in accordance with the ordinary meaning of that term.

125. Gerlach’s Figures 1, 3a, and 3b do not explicitly show a transmitter or receiver. However, it would have been obvious to a person of ordinary skill in the art that Gerlach’s network-based apparatus includes a transmitter and receiver, *i.e.* a transceiver. As discussed in Section X.B.2.b, Gerlach’s network-based apparatus transmits both probing signals and information signals. Specifically, in Gerlach, information signals 19 and probing signals 17 excite transmitting elements 14 “giving rise to transmission signals 18.” Gerlach, 2:44-49, 3:51-53, Fig. 3a.

126. A person having ordinary skill in the art would have understood that transmitting elements 14 in Gerlach’s network-based apparatus each must include a transmitter to effectuate the transmission of signals 18 to the remote devices. In addition, “[f]eedback signals 32 originate at receivers 16 in response to probing signals 17” and “are conveyed to weight computer 40 in array 12 for processing.” Gerlach, 3:43-48. Fig. 3a of Gerlach illustrates feedback signals being received directly at the weight computer of the network-based device. Although not explicitly depicted, a person having ordinary skill in the art would have understood that the feedback signals from the remote devices are transmitted wirelessly and necessarily received by receiving elements at the network-based apparatus before being provided to the weight computer and therefore, Gerlach’s network-based device also includes a receiver.

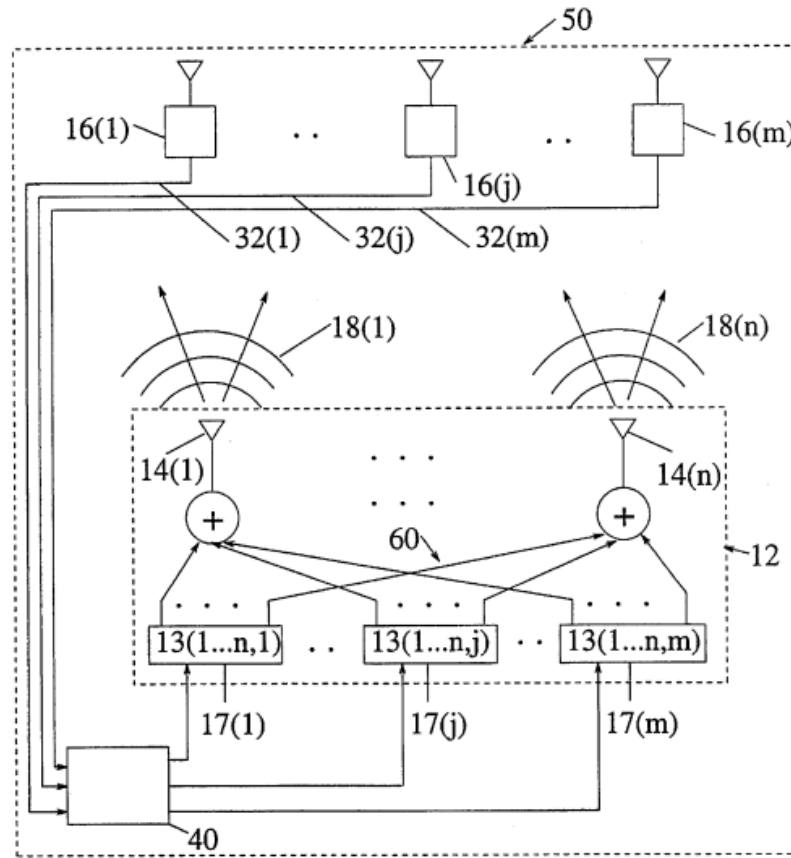
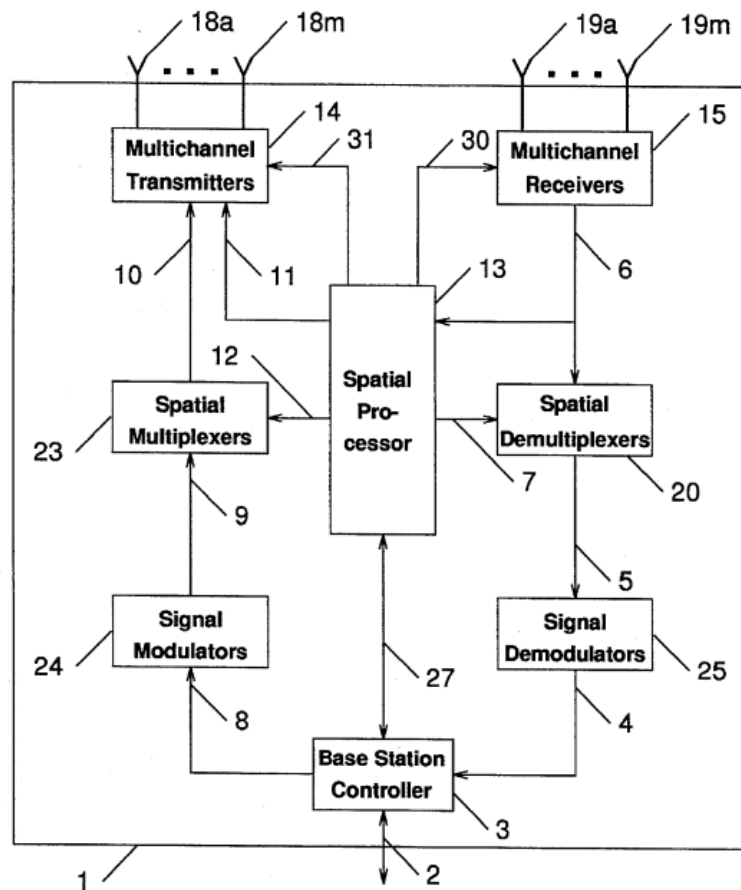


Fig. 3a

Gerlach, Fig. 3a

127. Moreover, Barrett explicitly discloses a “*transceiver*.” In particular, Figure 1 of Barratt shows, the base station includes multichannel transmitters 14 coupled between transmission antenna elements 18a-18n and spatial multiplexers 23 and also includes multichannel receivers 15 coupled between reception antenna elements 19a-19m. See Barratt, Fig. 1. During transmission, “signal modulators 24 produce modulated signals 9.” Barratt, 8:60-67. During reception, signal demodulators 25 are used to demodulate spatially separated uplink signals 5 from

the spatial multiplexers. Barratt, 8:38-42. As discussed in Section X.B.2.b, a person having ordinary skill in the art would have found it obvious to include signal modulators 24 and demodulators 25 in a “processor.” As shown in Fig. 1 of Barratt below, the multichannel transmitters 14 and multichannel receivers 15 are “operatively coupled to” modulators 24 and demodulators 25 (collectively the “processor”).



Barratt, Fig. 1

128. A person having ordinary skill in the art would have found it obvious to use Barratt’s transceiver to implement transmitting and receiving within Gerlach’s system for the reasons I discussed in Section X.B.1. Moreover, using Barratt’s transceiver to implement transmitting and receiving within Gerlach’s system would have amounted to no more than use of a known technique (Barratt’s transceiver) to improve similar devices (Gerlach’s network-based apparatus) in the same way (using a transceiver to effectuate Gerlach’s transmit and receive functionality).

129. Thus, in my opinion, the combination of Gerlach and Barratt therefore discloses or suggests “*a transceiver operatively coupled to the processor.*”

130. Even if the Patent Owner argues that a “transceiver” requires the transmitter and receiver to share components (a premise with which I disagree) the combination of Gerlach and Barratt would still teach a transceiver. As discussed in Section X.B.1 the transmission and reception elements in Barratt “are replaced by a single array of m antennas” where “[e]ach element in this array is attached to both its respective component of multichannel transmitters 14 and its respective component of multichannel receivers 15 **by means of a duplexer.**” Barratt, 20:30-35. Therefore, the transmitters and receivers in the combination of Gerlach and Barratt share at least an antenna array and a duplexer.

(i) “transmit the probing signal to at least the first client device and the second client device via a smart antenna”

131. In my opinion, the combination of Gerlach and Barratt discloses or suggests a transceiver configured to “transmit the probing signal to at least the first client device and the second client device via a smart antenna.” As discussed above in Section X.B.2.b(i), “each transmitting element 14 of array 12 is successively excited by a single probing signal 17” using a probing weight matrix W . Gerlach, 5:27-30.

132. Gerlach teaches that the probing signal is transmitted “via a smart antenna.” As discussed in Section X.B.2.b(i), “each transmitting element 14 of array 12 is successively excited by a single probing signal 17” using a probing weight matrix W . Gerlach, 5:27-30. As I will discuss below in more detail in Section X.B.2.c(ii), the antenna array 12 is part of a “smart antenna.” The probing weight matrix W is provided by the weight computer 40 to elements of Gerlach’s “*smart antenna*” (shaded blue in Fig. 3a below) and applied to the probing signal. The resulting signal 18 is transmitted via the transmitting elements 14 which include the recited “*transceiver*” and through the antenna array which is part of the “*smart antenna*.” The probing signal 17 is thus transmitted to each of the receivers 16(1) ... 16(m), as shown in the Fig. 3a below.

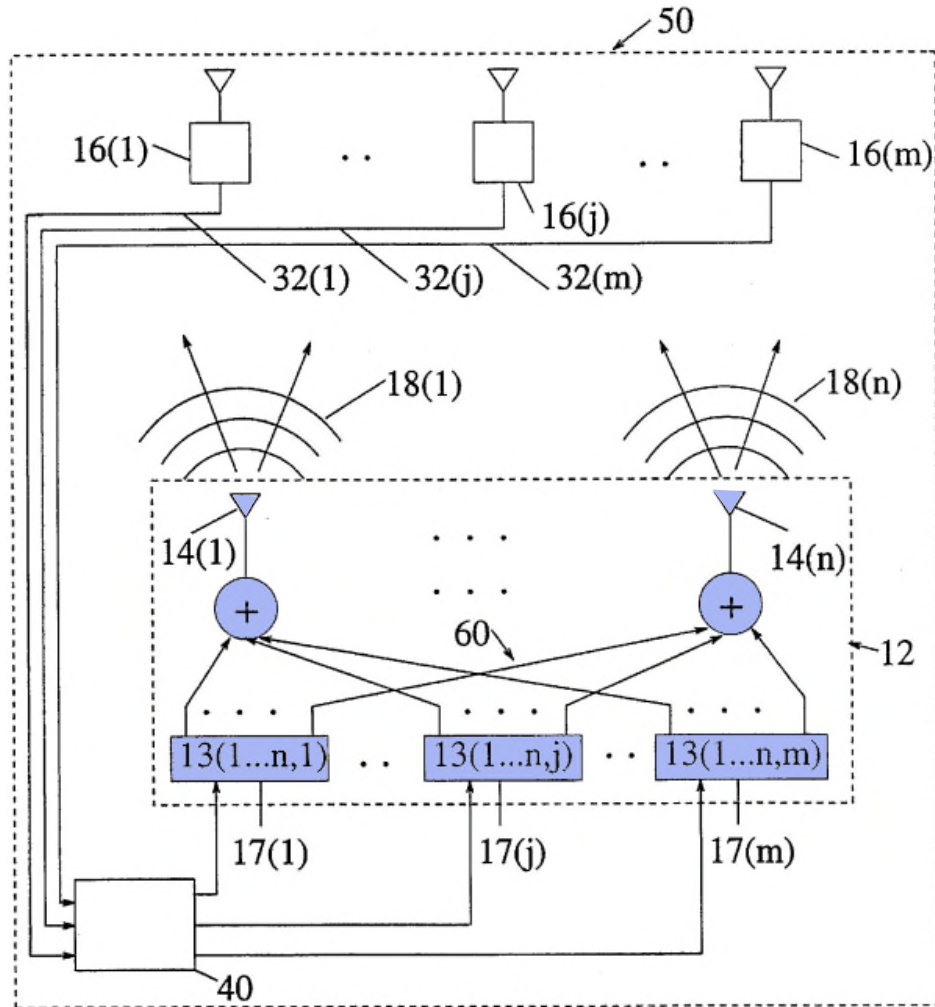


Fig. 3a

Gerlach, Fig. 3a (Annotated)

133. Accordingly, in my opinion, the combination of Gerlach and Barratt discloses or suggests a transceiver configured to transmit probing signals 17 to receiver 16(1) (“first client device”) and receiver 16(m) (“second client device”) via antenna array 12 which, as explained in the proceeding section, is part of a smart antenna.

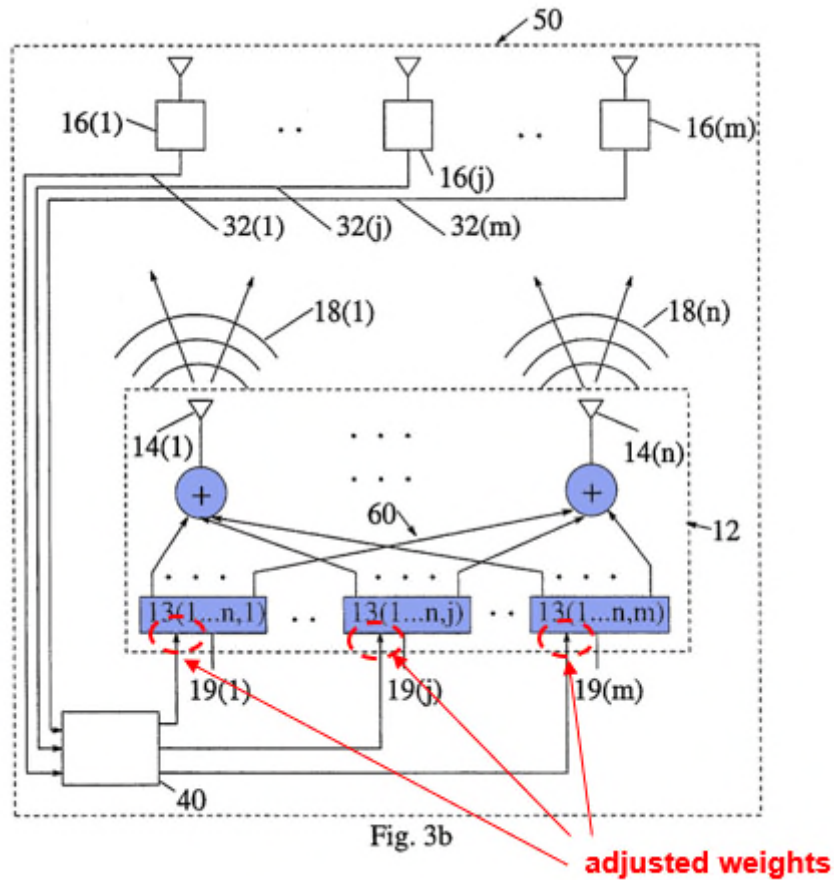
(ii) “wherein the smart antenna is operatively coupled to the transceiver and comprises a first antenna element and a second antenna element”

134. In my opinion, the combination of Gerlach and Barratt discloses or suggests “the smart antenna is operatively coupled to the transceiver and comprises a first antenna element and a second antenna element.” Array 12 comprises multiple antenna elements 14, including element 14(1)(“first antenna element”) and element 14(n)(“second antenna element”). *See, e.g.*, Gerlach, 1:6-9 (“The invention relates to methods for multiplexing signals transmitted from **an antenna array** to multiple receivers.”); 2:44-46 (“a conventional transmitting array 12 comprising transmission elements 14(1), 14(2), ... 14(n)”), Figs. 3a, 3b. The figures of Gerlach show transmitting elements 14 as including an antenna symbol (inverted triangle) for transmitting elements 14(1) and 14(n) and refers to transmitting elements as “antenna elements.” *See, e.g.*, Gerlach, 4:14-17, Figs. 1, 3a, 3b. Thus, antenna array 12 comprises “a first antenna element and a second antenna element.”

135. Barratt also discloses an “array of m antennas” where “[e]ach element in this array is attached to both its respective component of multichannel receivers 15 by means of a duplexer.” Barratt, 20:30-35. Thus, the combination of Gerlach and Barratt together also teaches an antenna array having “a first antenna element and a second antenna element.”

136. Gerlach's transmitting antenna array 12 includes a "*smart antenna*." In particular, Gerlach discloses that "transmitted signals 18(1) ... 18(n) are generated at elements 14(1)-14(n), respectively, by applying information signals 19(1)-19(m) to elements 14(1)-14(n) with selected complex amplitudes 15(1,1), 15(1,2) ... 15(n-1,m), 15(n,m) through connections 60." Gerlach, 2:62-67. These "complex amplitudes 15 form the elements of a $n \times m$ weight matrix W ." Gerlach, 2:67-3:1.

137. Gerlach's system "extract[s] information about the propagation environment from feedback signals 32 generated by transmission of selected probing signals 17." Gerlach, 5:4-8. The information conveyed by these feedback signals 32 is used to determine a new weight matrix W' . Gerlach, 5:8-10. The complex amplitudes making up weight matrix W' (e.g., 15(1...n, 1) - 15(1-n,m)) are then provided by weight computer 40 (as illustrated in Figure 3b below) to transmitting array 12. See Gerlach, 3:49-63, Fig. 3b. The beampattern created through by applying elements of weight matrix W' to an information signal "has a primary lobe 23(j) with unit gain at angle γ , in the direction of intended receiver 16(j), and side lobes 22(j) with nulls in the direction of all remaining receivers 16(l) where $l \neq j$." Gerlach, 3:35-39. That is, the beampattern is "directed" to receiver 16(j).



Gerlach, Fig. 3b (annotated)

138. Gerlach discloses that “changes in the location of receivers 16 or changes in the scattering environment will necessitate periodic reoptimization of complex amplitudes 15 comprising weight matrix W .” Gerlach, 3:14-17. Gerlach discloses two methods of reoptimization. First, the system can “monitor cross-talk during transmission of information signals 19” and initiates a “redetermination of weight matrix W ” whenever crosstalk increases above a preselected level.” Gerlach, 27-31. In the alternative, “weight matrix W can be reoptimized at regular intervals.”

Gerlach, 6:31-32. With either of these techniques, Gerlach's methods "determine the weight matrix W that generates complimentary null beampatterns for all signals 19." Gerlach, 6:32-35. The updated weight values are provided to the transmitting antenna array 12 as shown in the annotated Fig. 3b above. These weights are applied to subsequent transmissions of information signals.

139. In this way, weight computer 40 adjusts the weights (complex amplitudes) used in transmitting array 12 (shown as the parameters used in the blue boxes in annotated Fig. 3b above). The application of these weights in transmitting array 12 causes the adjustment of the beampattern generated by the transmitting array. For example, the direction of the main lobe and nulls of the beam can be altered based on the intended recipient and current status of the propagation environment. Indeed, Gerlach's method "us[es] feedback to optimize the directional properties." Gerlach, 1:48-51. Accordingly, weight computer 40, components of transmitting array 12 (highlighted blue in annotated Fig. 3b above) and the antenna array together are a "*smart antenna*" because these components allow the directed beampattern to be adjusted.

140. I am informed that the Patent Owner previously proposed in a District Court litigation concerning U.S. 7,062,296, which claims priority to the same provisional application as does the '376 patent, that the term "smart antenna" means "antenna that transmits directed beams." To the extent that Patent Owner advances

that construction for purposes of this proceeding and it is adopted, in my opinion, Gerlach teaches such an antenna. As discussed above, Gerlach's transmitting array 12 generates a null beampattern directed to the intended recipient device.

141. Specifically, Gerlach discloses that "Null beampattern 21 has a primary lobe 23(j) with unit gain at angle γ , in the direction of intended receiver 16(j), and side lobes 22(j) with nulls in the direction of all remaining receivers 16(l) where $l \neq j$." Gerlach, 3:35-39. As shown in Gerlach's Fig. 3b, the antenna elements, components of transmission array that adjust the generated beampattern, and the weight computer (collectively the "*smart antenna*") are coupled to the transmitter and receiver ("*transceiver*"). For transmitting array 12 to operate as intended (i.e., transmit signals), the "*smart antenna*" must be operatively coupled to transmitters (part of the "*transceiver*").

142. Accordingly, in my opinion, the combination of Gerlach and Barratt discloses or suggests that a smart antenna comprised of a first and second antenna elements that is operatively coupled to a transceiver.

- d. **“wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:”**
 - (i) **“receive a first feedback information from the first client device in response to the transmission of the probing signal” and “receive a second feedback information from the second client device in response to the transmission of the probing signal”**

143. In my opinion, the combination of Gerlach and Barratt discloses or suggest a processor, transceiver, and smart antenna configured to “receive a first feedback information from the first client device in response to the transmission of the probing signal” and “receive a second feedback information from the second client device in response to the transmission of the probing signal.”

144. Several equations describe the transmission and propagation environment of the Gerlach system. Gerlach teaches that “[s]ignal transmission between each element 14(1)-14(n) and each receiver 16(1)-16(m) is characterized by a transmission function or gain, comprising an amplitude and phase factor.” Gerlach, 3:64-67. The amplitude and phase factor are typically expressed as a complex amplitude at baseband:

$$a_{kj} = f_{kj} e^{i\theta(k,j)} \quad (\text{Eq. I})$$

“where a_{kj} is the transmission factor between array element 14(k) and receiver 16(j), and f_{kj} and $\Theta(k,j)$ are the corresponding amplitude and phase.” Gerlach, 3:67-4:6.

The transmission functions a_{kj} for each array-element/receiver pair “are conveniently represented as the matrix elements of an n by m gain matrix, A , where n is the number of antenna elements 14 and m is the number of receivers 16.” Gerlach, 4:14-17. For example, “the j^{th} column of A contains transfer functions between receiver 16(j) and transmission elements 14(1)-14(n).” Gerlach, 4:18-20.

145. Gerlach provides the following equation to represent the amplitude of a received signal corresponding to information signal 19(j) at an individual receiver (e.g., receiver 16(1) above) due to all transmitting elements 14:

$$c_{ji} = \sum w_{jk}^H a_{ki} \quad (\text{Eq. III})$$

See Gerlach, 4:44-47. In this equation, c_{ji} “is the amplitude of information signal 19(j) at receiver 16(i) and the summation is over all transmitting elements 14(1)-14(n).” Gerlach, 4:48-50. The c_{ji} “taken together form elements of a signal matrix C .” Gerlach, 4:54-55.

146. Gerlach summarizes the transmission properties for the wireless system with the following equation:

$$147. \quad W^H A = C \quad (\text{Eq. IV})$$

Gerlach, 4:56-59. In Equation IV, A is the gain matrix which “characterizes the geometric properties of wireless system 50.” Gerlach, 4:17-18. And “ W^H is the Hermitian conjugate of the weight matrix W according to which information signals

19 or probing signals 17 are applied to transmitting elements 14, and C is the matrix representation of the resulting probing signals 17 or information 19 at receivers 16.” Gerlach, 4:60-64.

148. In Gerlach, “[f]or a given gain matrix A, a new weight matrix W’ can be found that eliminates the off-diagonal elements of signal matrix C.” Gerlach, 4:64-66. In the signal matrix, for $i=j$, “ c_{ji} represents the amplitude of information signal 19(j) at its intended receiver 16(j), while for ($i \neq j$) c_{ji} represents cross-talk due to information signal 19(j) at the receiver 16(i).” Gerlach, 4:50-53. Thus, the off-diagonal components represent “cross-talk”—i.e, non-zero amplitude of an information signal not intended for the recipient. Gerlach’s system makes these elements zero, thereby eliminating the element of the signal matrix. Equation IV above therefore becomes:

$$W'^H A = I \quad (\text{Eq. V})$$

“where, I is the identity matrix.” Gerlach, 4:67-5:3. A person having skill in the art would have understood that this calculation requires that each column of W’ to be matched with a column A (i.e., the column index of W’ matches the receiver providing feedback for the column).

149. With this in mind, Gerlach teaches that its system “facilitates diagonalization of signal matrix C **by extracting information about the propagation environment from feedback signals 32** generated by transmission of

selected probing signals 17 in accordance with weight matrices W.” Gerlach, 5:4-8. The information included in and extracted from each feedback signal is the recited “feedback information.”

150. As shown in annotated Fig. 3a below, “each transmitting element 14 of array 12 is successively excited by a single probing signal 17, and **the response at all receivers is measured and fed back for each excitation.**” Gerlach, 5:27-30. Each transmission of a probing signal results in feedback signals from each client device in communication range of the transmitting array. The annotations to Fig. 3a below left, shows the system receiving first and second feedback information (e.g., feedback signals 32(1) and 32(m)) from the first and second client device (e.g., receivers 16(1) and 16(m)) in response to the probing signal (e.g., probing signal 17(1)). The annotations to Fig. 3a below right, shows the system receiving first and second feedback information (e.g., feedback signals 32(1) and 32(m)) from the first and second client device (e.g., receivers 16(1) and 16(m)) in response to a different probing signal (e.g., probing signal 17(m)).

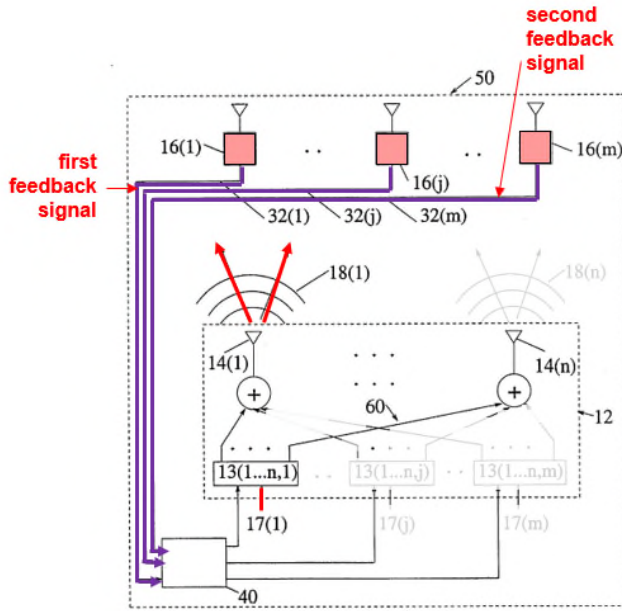


Fig. 3a

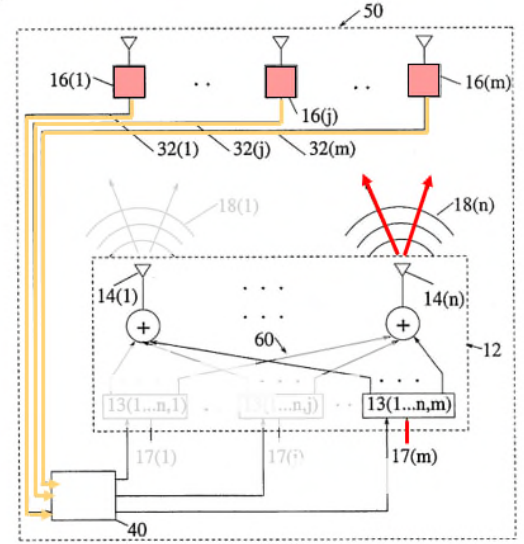


Fig. 3a

Gerlach, Fig. 3a (annotated)

151. Accordingly, in my opinion, the combination of Gerlach and Barratt teaches that receiving feedback signal 32(1) (“receive a first feedback information”) from receiver 16(1) (“from the first client device”) in response to probing signal 17(1) (“in response to the transmission of the probing signal”). Likewise, the combination of Gerlach and Barratt discloses or suggests receiving feedback signal 32(m) (“receive a second feedback information”) from receiver 16(m) (“from the second client device”) in response to probing signal 17(1) (“in response to the transmission of the probing signal”).

152. Gerlach discloses:

Feedback signals 32 originate at receivers 16 in response to probing signals 17 applied to transmitting elements 14, according to complex amplitudes 13. Feedback signals 32 are conveyed to weight computer 40 in array 12 for processing.

Gerlach, 3:45-47.

153. Although Fig. 3a does not explicitly show how the feedback signals are conveyed, a person having ordinary skill in the art would have understood that the feedback signals are necessarily received by a receiver at the network-based device and provided to the weight computer after appropriate signal processing. Barratt explicitly discloses receivers and the general process of receiving an uplink signal at the base station's antenna array. See Section VIII.B; Barratt, 6:63-67, 7:53-58. Accordingly, in my opinion, in the combination of Gerlach and Barratt, each of the feedback signals is received by "*the transceiver*" and the "*smart antenna*."

154. In addition, a person having ordinary skill in the art would have understood that a received signal must be demodulated before the information carried in the signal is useable by a processor. Moreover, as discussed in Section X.B.2.b, a person having ordinary skill in the art would have been motivated to use a processor for signal modulation and demodulation as well as for the weight computer processes. Because the first feedback information is demodulated and provided to the weight computer, the "*processor*" in the combination of Gerlach and Barratt also receives the first feedback information.

155. Accordingly, in my opinion, the combination of Gerlach and Barratt discloses or suggests that each of the processor, the transceiver and the smart antenna are configured to perform the functions of “receiv[ing] the first feedback information” and “receiv[ing] the second feedback information.”

(ii) “determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information”

156. In my opinion, the combination of Gerlach and Barratt discloses or suggests a smart antenna configured to “determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information.”

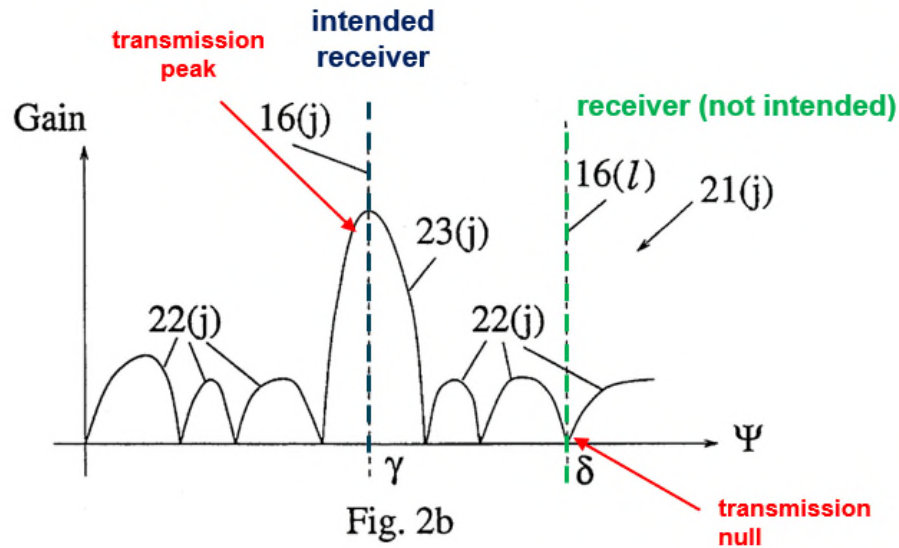
157. For example, Gerlach discloses using “feedback signals 32 to adjust the amplitudes and phases 15 with which signals 19 are applied to transmitting elements 14 so that cross-talk is minimized.” Gerlach, 3:30-34.

158. When the number of transmitting elements is greater than the number of receivers, this new weight matrix W' is calculated by the weight computer 40 and used to “generate a complimentary null beampattern” for subsequent information transmissions in the network. Gerlach, 5:19-21. Thus, Gerlach’s weight computer

determines the weight matrix values necessary to generate a complimentary null beampattern to transmit an information signal to an intended recipient.

159. A complimentary null beampattern includes “*transmission peaks*” and “*transmission nulls*.” A beampattern (or antenna pattern) is the “graphical representation of the radiation (far-field) properties of an antenna.” Stutzman, at 33. Thus, each of the beampatterns produced by the transmitting elements of Gerlach’s array is a “*spatially distributed pattern[] of electromagnetic signals*.” The primary lobe (main lobe) (i.e., the “*transmission peak*”) of the beampattern is the lobe containing the direction of maximum radiation. See Stutzman, at 44. A null (i.e., “*transmission null*.”) is the direction in which the pattern assumes very small values, ideally zero.

160. Figure 2b shows that null beampattern 21 for a single information signal having elements of weight matrix W' applied, “has a primary lobe 23(j) with unit gain at angle γ , in the direction of intended receiver 16(j), and side lobes 22(j) with nulls in the direction of all remaining receivers 16(l) where $l \neq j$.” Gerlach, 3:35-38.



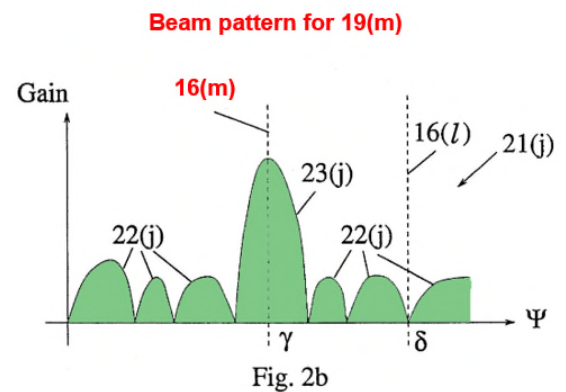
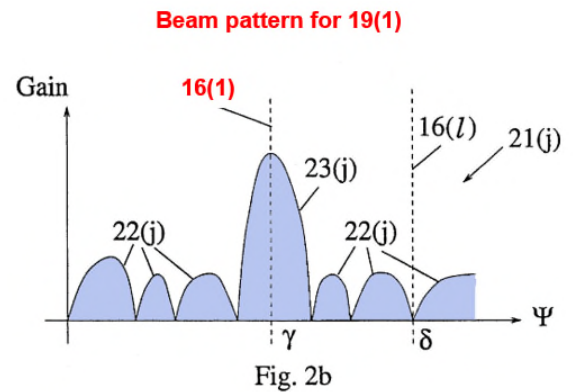
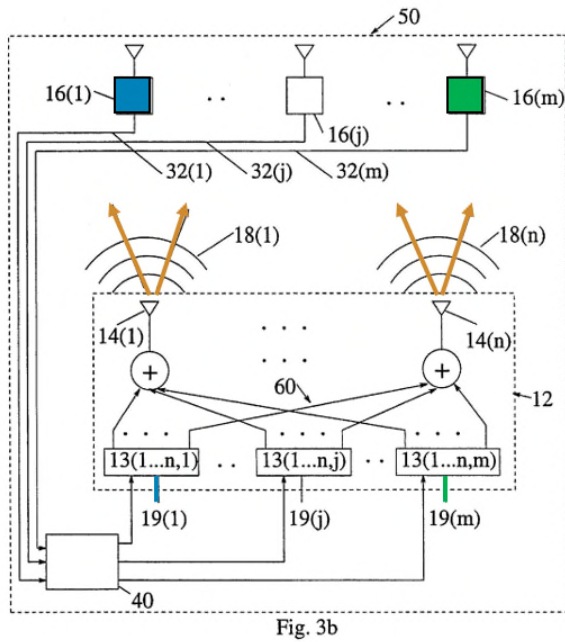
Gerlach, Figure 2b (annotated)

161. Gerlach teaches that “[w]ireless communication systems may use spatial multiplexing techniques wherein a single transmitter simultaneously emits multiple information signals, each of which is intended for one of a number of spatially separated receivers.” Gerlach, 1:13-17.

162. The “directional properties of transmitting antenna arrays are exploited in” systems using spatial multiplexing techniques “to generate a beampattern for each signal which is directed towards its intended receiver.” Gerlach, 1:17-19; *see also id.*, 3:20-22 (“Each information signal 19 will have its own beampattern 21 generated by interference between transmission signals 18.”).

163. Each of the m information signals 19 (signals 19(1) to 19(m)) in Fig. 3b) have a null beampattern like that shown in Fig. 2b. Thus, a null beampattern is

generated for a first information signal directed to a first receiver (e.g., signal 19(1) directed to receiver 16(1) shown in the Fig. 2b top below) that has a primary lobe in the direction of the first receiver and nulls directed to other receivers. And a separate null beam pattern is generated for a second information signal directed to a second receiver (e.g., signal 19(m) directed to receiver 16(m) shown in Fig. 2b bottom below) that has a primary lobe in the direction of the second receiver and nulls directed to all other receivers.



Gerlach, Annotated Figures 3b, 2b

164. As discussed in Section X.B.2.c(ii), the weight computer is part of the “smart antenna.”

165. Thus, in my opinion, the combination of Gerlach and Barratt discloses or suggests that the “smart antenna” is configured to “determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information.”

(iii) “transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals” and “transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals”

166. In my opinion, the combination of Gerlach and Barratt discloses each of a smart antenna and transceiver configured to “transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals” and to “transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals.”

167. Gerlach is directed “to methods for multiplexing signals transmitted from an antenna array to multiple receivers.” Gerlach, 1:6-7. Gerlach teaches that the “transmitter simultaneously emits multiple information signals, each of which is intended for one of a number of spatially separated receivers.” Gerlach, 1:13-17.

168. Gerlach further explains that “[i]nformation signals 19 are directed toward their intended receivers 16” by applying them “to elements 14(l)-14(n) with selected complex amplitudes 15(1,1), 15(1,2) ... 15(n-1,m), 15(n,m) through connections 60.” Gerlach, 2:62-67. The “[i]nteraction among resulting signals 18(1)-18(n) directs information signals 19 to their intended receivers 16.” Gerlach, 3:1-3. In other word, this “interaction among resulting signals 18(1)-18(n)” is the beampattern associated with the signal. As discussed above, a beampattern (or antenna pattern) is a “spatially distributed pattern[] of electromagnetic signals.”

169. Each information signal has “its own beampattern 21 generated by interference between transmission signals 18.” Gerlach, 3:20-22. As depicted in Fig. 3b reproduced below, information signal 19(1) (“first data stream”) is transmitted via antenna elements 14 to receiver 16(1) (“the first client device”). A different information signal 19(m) (“second data stream”) is simultaneously directed to receiver 16(m) (the second client device”).

170. In Fig. 3b, weights for signal 19(1) are selected for the propagation environment between transmitting array 12 and receiver 16(1)—that is, the column⁵

⁵ Generally, Gerlach teaches that for any particular weight matrix W , “[c]omplex weight w_{kj} is $(kj)^{\text{th}}$ element of weight matrix W , and the j^{th} column of matrix W

of weight matrix W' for receiver 16(1) is provided to transmitting array 12 (e.g., 15(1 ...n, 1). Likewise, the weights for signal 19(m) are selected for the propagation environment between transmitting array 12 and receiver 16(m)—that is, the column of weight matrix W' for receiver 16(m) is provided to transmitting array 12 (e.g., 15(1 ...n, m). Information signal 19(1) is applied to elements 14(1)-14(n) with the selected weights provided to the highlighted blue box and information signal 19(m) is simultaneously applied to elements 14(1)-14(n) with the selected weights provided to the highlighted green box.

171. The components of each weighted information signal are combined at an adder associated with each transmitting element 14 and the resulting signals are transmitted by transmission elements 14.

corresponds to weight vector w which characterizes the complex amplitudes with which probing signal 17(j) or information signal 19(j) is applied to transmitting elements 14.” Gerlach, 4:35-39.

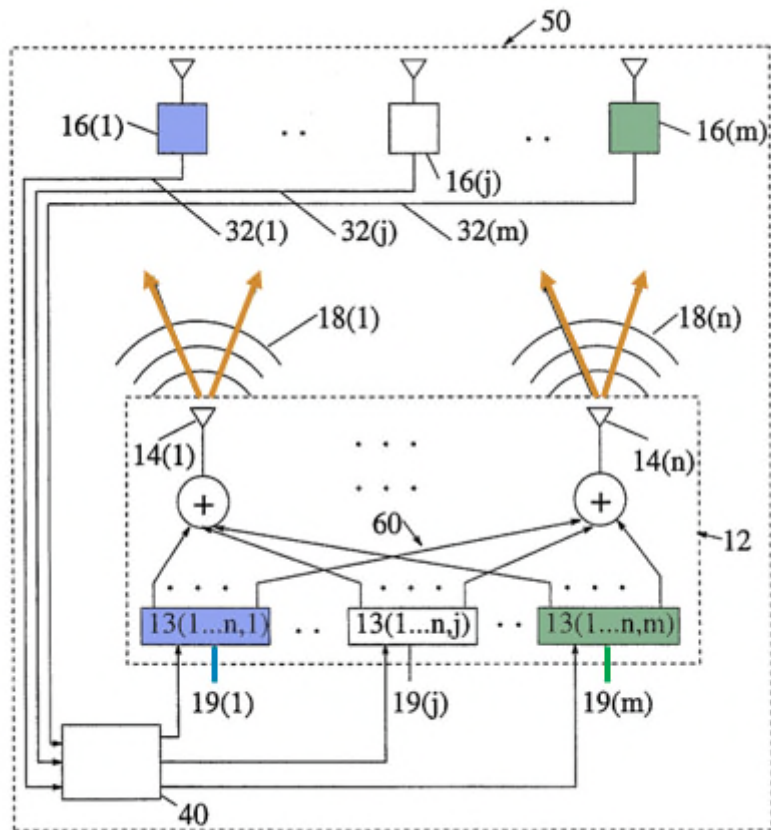


Fig. 3b

Gerlach, Fig. 3b (annotated)

172. The “processor” in the combination of Gerlach and Barratt generates the modulated information signals s (see Section X.B.2.b). The transmission of each information signal 19 occurs via the smart antenna and transceiver (see Section X.B.2.c).

173. Thus, the combination of Gerlach and Barratt teaches each of a smart antenna and transceiver configured to transmit information signal 19(1) (“transmit the first data stream”) to receiver 16(1) (“to the first client device”) via spatially distributed patterns of electromagnetic signals and to transmit information signal

19(m) (“transmit the first data stream”) to receiver 16(m) (“to the first client device”) via spatially distributed patterns of electromagnetic signals.

e. “wherein transmission of the first data stream and transmission of at least part of the second data stream occur at the same time; and”

174. In my opinion, the combination of Gerlach and Barratt discloses or suggests the “transmission of the first data stream and transmission of at least part of the second data stream occur at the same time.”

175. Gerlach is directed “to methods for multiplexing signals transmitted from an antenna array to multiple receivers.” Gerlach, 1:6-7. The spatial multiplexing techniques disclosed by Gerlach allow a “single transmitter [to] *simultaneously* emit[] multiple information signals, each of which is intended for one of a number of spatially separated receivers.” Gerlach, 1:13-17. As discussed in Section VIII.A, Gerlach’s probing/feedback technique is integrated with conventional SDMA, described above with respect to Fig. 1. For example, Gerlach discloses that, as implemented in Fig. 3b, “[i]nformation signals 19(1), 19(2) ... 19(m) excite transmitting elements 14(1)-14(n) *collectively*, giving rise to transmission signals 18 which are detected by receivers 16(1)-16(m), respectively.” Gerlach, 2:47-50. Moreover, Gerlach’s system is directed “to methods for multiplexing signals from an antenna array to multiple receivers, and in particular to the use of feedback from the receivers to minimize **cross-talk among the received**

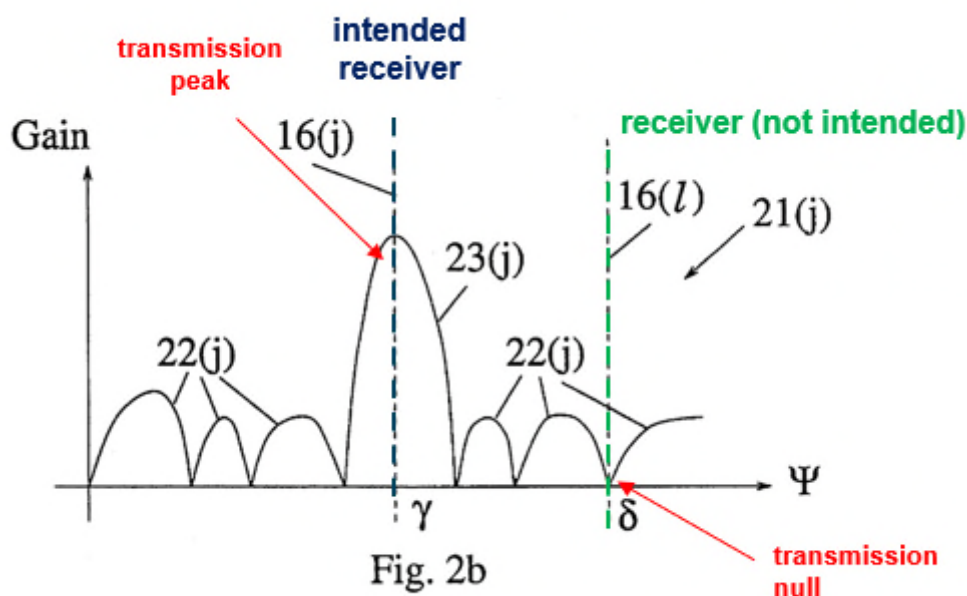
signals.” Gerlach, 1:8-9. Thus, Gerlach teaches transmitting the information signals “*simultaneously*” in way that minimizes cross-talk between the signals.

176. Accordingly, the combination of Gerlach and Barratt discloses or suggests transmitting information signals 19(1) (“the first data stream”) and 19(j) (“the second data stream”) at the same time.

f. “wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.”

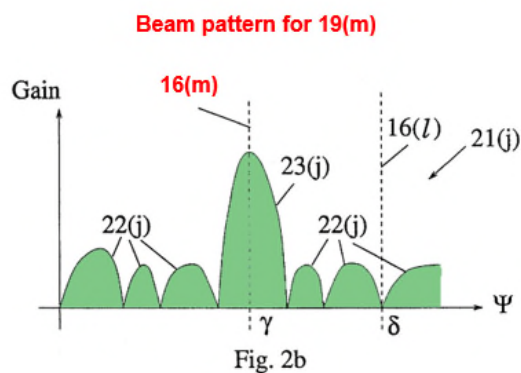
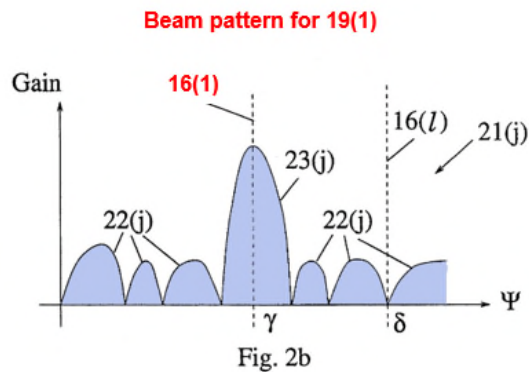
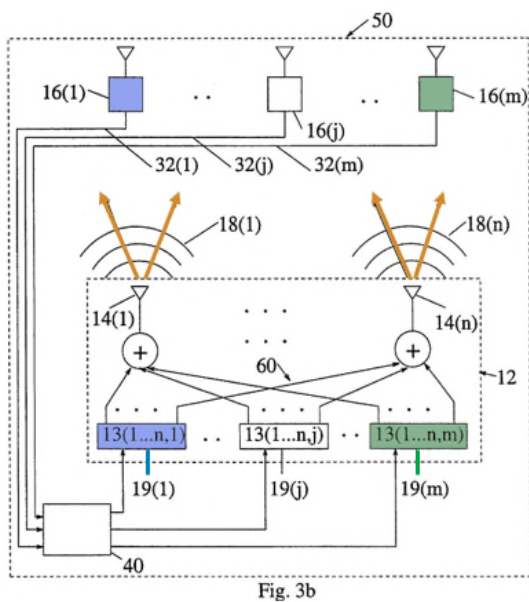
177. In my opinion, the combination of Gerlach and Barratt discloses or suggests “the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device.”

178. As discussed above in Section X.B.2.d, transmitting array 12 “generate[s] a complimentary null beam pattern” using the adjusted weight matrix W' . Gerlach, 5:20-22. A complimentary null beampattern 21 has a “primary lobe 23(j) with unit gain at angle γ , in the direction of intended receiver 16(j), and side lobes 22(j) with nulls in the direction of all remaining receivers 16(l) where $l \neq j$ ” as illustrated in Fig. 2b. Gerlach, 5:36-39. Thus, a transmission directed at receiver 16(1) (first client device) would have a beampattern including a primary lobe (a first transmission peak) at that receiver and a transmission null at all other receivers.



Gerlach, Figure 2b (annotated)

179. Gerlach explains that “[e]ach information signal 19 will have its own beampattern 21 generated by interference between transmission signals 18.” Gerlach, 3:20-22. Multiple beampatterns, like that shown in Fig. 2b exist for the simultaneous communication of each information signal. The below figures (at right) annotate Fig. 2b to show “complimentary null beampattern” 21(1) directed to receiver 16(1) carrying information signal 19(1) (top) and “complimentary null beampattern” 21(m) directed to receiver 16(m) carrying information signal 19(m) (bottom). Both beampatterns exist when information signal 19(1) and 19(m) are transmitted simultaneously.



Gerlach, Annotated Figures 3b, 2b

180. Accordingly, in my opinion, the combination of Gerlach and Barratt teaches that the spatially distributed patterns of electromagnetic signals exhibits a primary lobe shown as peak 23 for information signal 19(1) (first transmission peak) at the location of receiver 16(1) (first client device) and a primary lobe peak 23 for information signal 19(m) (second transmission peak) at the location of receiver 16(m) (second client device).

3. Claim 12

181. Claim 12 is identical to claim 1, except that claim 12 adds a requirement of “a first transmission null at a location of a third device.”⁶

182. In my opinion, the combination of Gerlach and Barratt also discloses or suggests the additional requirement of “a first transmission null at a location of a third device.” For example, Gerlach explains that, when transmitting an information signal directed to any particular receiver such as receiver 16(j), “[n]ull beampattern 21” has “nulls in the direction of all remaining receivers 16(l) where $l \neq j$.” Gerlach, 3:34-39. In other words, the beampattern 21 for any given information signal 19 “*exhibit[s] a first transmission peak at a location of the first client device*” and “*a transmission null*” at all other receivers (i.e., “*a location of a third device*”).

183. As discussed above, in Section X.B.2.f, the below figures (at right) annotate Fig. 2b to show “complimentary null beampattern” 21(1) directed to receiver 16(1) carrying information signal 19(1) (top) and “complimentary null beampattern’ 21(m) directed to receiver 16(m) carrying information signal 19(m)

⁶ Claim 12 also omits the phrases “in response to the transmission of the probing signal” as compared with claim 1, but this broadening does not alter the reasons why the combination of Gerlach and Barratt discloses or suggests each element of claim 12. See Sections X.B.2 to X.B.2.f.

(bottom). For either of these beampatterns there would be a null at the location of receiver 16(*l*).

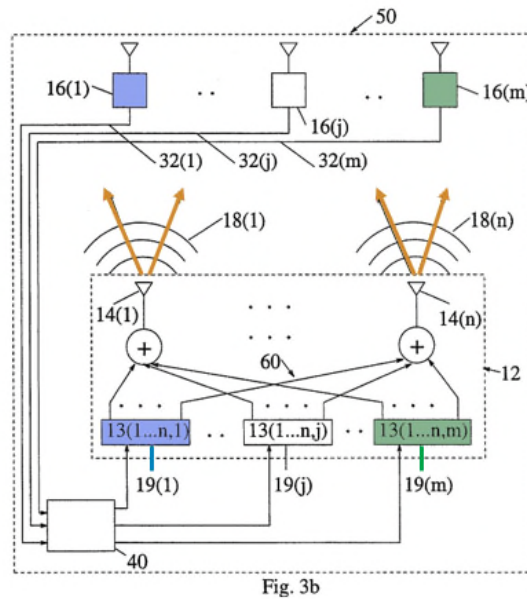


Fig. 3b

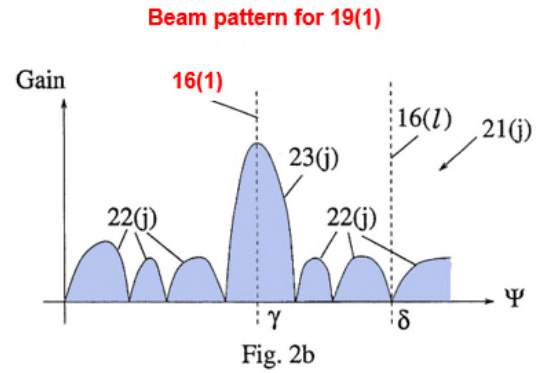


Fig. 2b

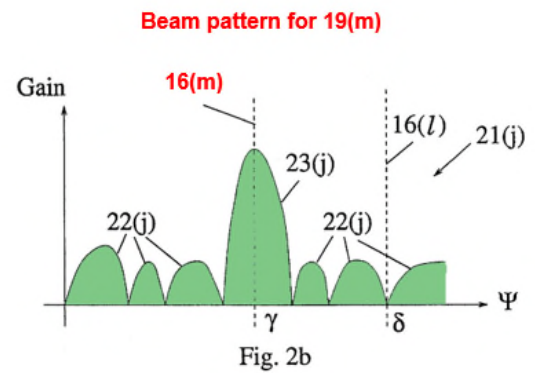


Fig. 2b

Gerlach, Annotated Figures 3b, 2b

184. Accordingly, in my opinion, the combination of Gerlach and Barratt discloses or suggests including a spatially distributed pattern of electromagnetic signals that exhibits a null (“a first transmission null”) in the direction of receiver 16(*l*) (“at a location of a third device”). Thus, in my opinion, for the reasons discussed above in connection with claim 1 (*see* sections X.B.2.a through X.B.2.f), the combination of Gerlach and Barratt discloses or suggests each element of claim 12.

4. Claim 22

185. Claim 22 is substantively identical to claim 1, except for the addition of two limitations: “wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table” and “wherein the second feedback information comprises one or more of: a second amplitude information, a second phase in-formation, a second routing information, or a second index to a routing table”.⁷ Thus, in my opinion, for the reasons discussed above in connection with claim 1 (see Sections X.B.2.a through X.B.2.f), the combination of Gerlach and Barratt discloses all other corresponding elements.

⁷ I also understand that when compared to claim 1, claim 22 also omits the phrases “and comprises a first antenna element and a second antenna element” and “in response to the transmission of the probing signal”, and changes “at the same time” to “simultaneously.” These changes do not alter the reasons why the combination of Gerlach and Barratt discloses each element of claim 22.

- a. **“wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table” and “wherein the second feedback information comprises one or more of: a second amplitude information, a second phase information, a second routing information, or a second index to a routing table”**

186. In my opinion, the combination of Gerlach and Barratt also teaches the limitations “wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table” and “wherein the second feedback information comprises one or more of: a second amplitude information, a second phase information, a second routing information, or a second index to a routing table.”

187. First, the feedback information received in Gerlach’s system includes “amplitude information” and “phase information.” As discussed in Section VIII.A, probing signals 17 are “transmitted with a selected weight matrix W , and the resulting feedback (32) used to determine the transfer functions a_{kj} for each array-element/receiver pair.” Gerlach, 1:57-60, 5:11-14 (“Information conveyed by feedback signals 32 can then be used to determine weight matrix W' of equation V”). The transmission functions a_{kj} “are conveniently represented as the matrix elements of an n by m gain matrix, A , where n is the number of antenna elements 14 and m is the number of receivers 16.” Gerlach, 4:14-17.

188. The determination of gain matrix A from feedback signals 32 “is facilitated by using a probing weight matrix W with elements $13(1,1) \dots 13(n,m)$ having all components zero except for 1s in the diagonal position.” Gerlach, 5:22-25. Thus, “[e]ach column of W is a weight vector w_j which picks out a corresponding row of gain matrix.” Gerlach, 5:27-30. Gerlach teaches that “each transmitting element 14 of array 12 is successively excited by a single probing signal 17.” Gerlach, 5:27-29. The “**response** at all receivers 16 is measured **and fed back** for each excitation.” Gerlach, 5:29-30. The “[s]equential application of each weight vector w_j allows sequential measurement of each row of gain matrix A , because signal matrix C equals gain matrix A in this case.” Gerlach, 5:30-33. In other words, $c_{ji} = a_{ji}$. Thus, Gerlach teaches that the probing signal response (the measured amplitude of information 19(j) at receiver (i) due to all transmitting elements) is provided in the feedback signal. The “transmission function or gain” comprises both “an amplitude and phase factor” that are “typically expressed as a complex amplitude.” Gerlach, 3:67-4:6. Because the complex amplitude a_{ji} includes an “amplitude and phase factor,” the “feedback information” received from each remote device includes “amplitude information” and “phase information.”

189. Second, Gerlach also discloses that the feedback information can be an index to a routing table. For example, Gerlach discloses:

Information conveyed by feedback signals 32 can then be used to determine weight matrix W' of equation V. Information signals 19 transmitted according to weight matrix W' ideally will have no cross-talk.

190. Gerlach, 5:7-10. In particular, Gerlach discloses that the weight matrix is used “for the distribution of information signal (19) among the array elements (14) that minimizes cross-talk.” *Id.*, 1:60-63, 4:64-66, 5:19-20 (“weight matrix W' ... will generate a complimentary null beampattern”).

191. The feedback information received in the network-based apparatus of Gerlach also includes an “index to a routing table.” The routing table disclosed in the '376 patent is described as follows: “The routing table(s) or similar data structure(s) provide an information basis for each routing decision within the wireless communication system (e.g., multi-beam directed signal system 206).” ’376 patent, 15:59-62. The routing table of the '376 patent includes “identifiers of the desired sources” and “stored weighting values (w) each associated with a particular signal source.” *Id.*, 24:45-49. In my opinion, Gerlach teaches or at a minimum suggests such a “*routing table*.”

192. A person having ordinary skill in the art would have recognized that weight matrix W' is a “routing table” because it provides information for directing a beampattern carrying an information signal to an intended destination within the wireless communication system of Gerlach. As discussed in Section VIII.A,

Gerlach's weight matrix W' is determined from gain matrix A , which in turn has its columns ordered and indexed based on the feedback information received from receivers 16 in response to probing signals 17. Gerlach, 5:11-14, 5:33-35. A person having ordinary skill in the art would have understood that received signals include an identifier of remote device that transmitted the feedback to serve as an index and identifier to permit placement of the feedback complex amplitudes in the correct column of matrix A and correctly maintain calculated weights in the corresponding column of matrix W' , which would in turn generate beampatterns to route the data signal to the remote device.

193. Gerlach confirms that its feedback signals include an identification of the transmitting receiver 16. In Gerlach, each column of matrix W' is designated for a specific receiver. Gerlach, 2:67-3:1; *see also id.*, 2:50-52. Gerlach explains that matrix W' is calculated from gain Matrix A , which itself is determined based on feedback information from receivers 16. Gerlach, 5:11-14, 5:33-35.

194. For a receiver 16(j), "the j^{th} column of A contains transfer functions between receiver 16(j) and transmission elements 14(l)-14(n)." Gerlach, 4:18-20.

195. As discussed earlier, Gerlach discloses in (Eq. V) that W' is calculated according to

$$W'^H A = I \quad (\text{Eq. V})$$

“where, I is the identity matrix.” Gerlach, 4:67-5:3. The j^{th} column of matrix W (determined from gain matrix A) “corresponds to weight vector w_j , which characterizes the complex amplitudes with which probing signal 17(j) or information signal 19(j) is applied to transmitting elements 14.” Gerlach, 4:35-39. Thus, in order to populate the columns of matrix A with information received in the feedback signals and to generate the columns of W' from matrix A , Gerlach’s weight computer 40 must know from which receiver 16 the feedback information originated because of the index.

196. A person having ordinary skill in the art would have understood that the calculation of W' from gain matrix A requires that each column of W' be indexed and matched with the column of A , i.e., the column index of W' matches the receiver that provided the feedback for the column of A . In other words, the weights for a receiver, for example 16(j), in W' must be placed in the column corresponding to the column of A that contains the receiver 16(j)’s feedback.

197. Absent such identification of the receivers, the antenna array 12 would not be able to distinguish among signals sent from the various receivers. Thus, like the ’376 patent, Gerlach’s weight matrix W' includes identifiers of the desired sources and stores weighting values (w) each associated with a particular signal source. Accordingly, a person having ordinary skill in the art would have understood

the weights for receiver 16(j) in W' must be placed in the column corresponding to the column of matrix A containing the receiver 16(j)'s feedback.

198. Moreover, Gerlach's weight computer 40 selects a particular column from weight matrix W' to apply to an information signal destined for a specific receiver. See Gerlach, Fig. 3b. For example, weights for signal 19(1) are selected for the propagation environment between transmitting array 12 and receiver 16(1)—that is, the column of weight matrix W' for receiver 16(1) is provided to transmitting array 12 (e.g., 15(1 ...n, 1). Likewise, weights for signal 19(m) are selected for the propagation environment between transmitting array 12 and receiver 16(m)—that is, the column of weight matrix W' for receiver 16(m) is provided to transmitting array 12 (e.g., 15(1 ...n, m). Thus, Gerlach's weight computer 40 uses the identifier of the receiver (e.g., 16(1) or 16(m)) as an index to the weight matrix W' .

199. Thus, Gerlach discloses or suggests that the “feedback information” includes an “index to a routing table” (identification of the receiver 16).

200. Thus, in my opinion, the combination of Gerlach and Barratt discloses or suggests “wherein the first feedback information comprises one or more of: a first amplitude information, a first phase information, a first routing information, or a first index to a routing table” and “wherein the second feedback information comprises one or more of: a second amplitude information, a second phase information, a second routing information, or a second index to a routing table,”

including feedback signal 32(l) (“first feedback information”) and feedback signal 32(j) (“second feedback information”) that comprise a first and second index to a matrix W' (“index to a routing table”), respectively.

5. Claim 32

201. Claim 32 is substantively identical to claim 22, except for the addition of limitation “a memory operatively coupled to one or more of the processor or the transceiver; wherein a routing table is stored in the memory” and the requirement that “the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit ... a first transmission null at a location of a third device.” For the reasons, discussed above in Section X.B.3, the combination of Gerlach and Barratt discloses or suggests “the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit ... a first transmission null at a location of a third device. For the reasons discussed above in Section X.B.4 in connection with claim 22, the combination of Gerlach and Barratt discloses or suggests the other elements of claim 32.

a. **“a memory operatively coupled to one or more of the processor or the transceiver; wherein a routing table is stored in the memory”**

202. In my opinion, Gerlach and Barratt teaches “a memory operatively coupled to one or more of the processor or the transceiver; wherein a routing table is stored in the memory.”

203. As discussed above in Section X.B.4.a, weight matrix W' is a routing table. As discussed above in Sections VIII.A and X.B.2.d(i), Gerlach's system uses the "[i]nformation conveyed by feedback signals 32" to determine a new weight matrix, W' , for application during information system transmission. Gerlach, 5:8-10. Fig. 3b below shows that the weight computer provides the appropriate elements of the weight array to components in the transmitting array, based on the information signals to be transmitted and the intended reception. For example, for information signal 19(1) destined for receiver 16(1), the weight computer provides the weight array column associated with receiver 16(1) (i.e., 15(1 ... ,n, 1) (provided in box shaded blue) and for information signal 19(m) destined for receiver 16(m), the weight computer provides the weight array column associated with receiver 16(m) (i.e., 15(1 ... ,n,m) (provided in box shaded green). Using these adjusted weight matrix values, transmitting array 12 "generate[s] a complimentary null beam pattern." Gerlach, 5:20-22. In that way, Gerlach's system "routes" the directed beam carrying information signal 19(1) to receiver 16(1) and the directed beam carrying information signal 19(m) to receiver 16(m).

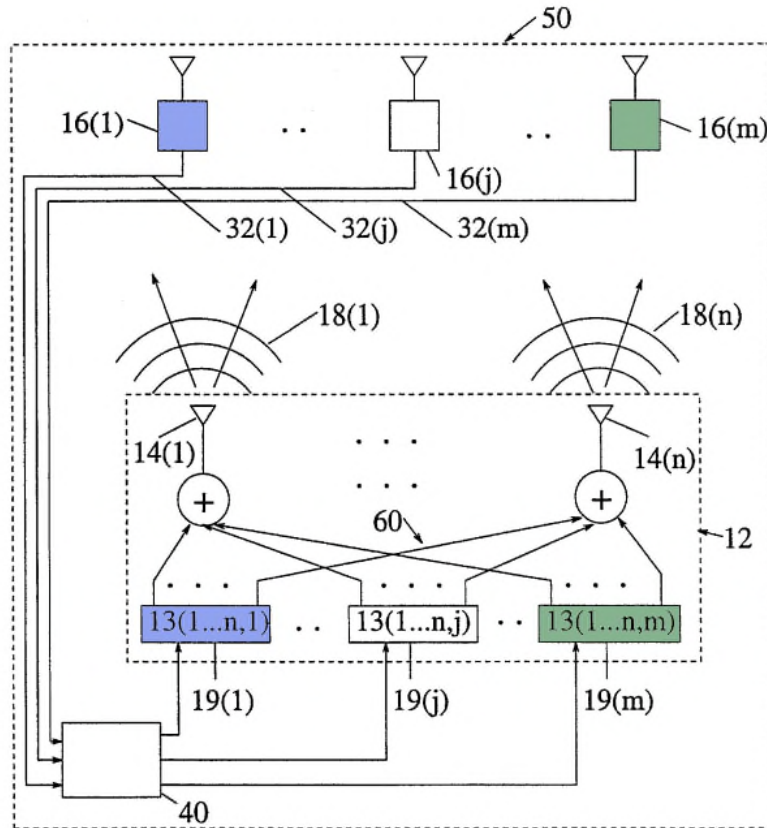


Fig. 3b

Gerlach, Figure 3b (annotated)

204. Although Gerlach does not explicitly mention the use of a memory to store weight matrix W' , a person having ordinary skill in the art would have understood that such a memory would be necessary, or at least obvious, to include in Gerlach's system to store the data including weight matrix W' needed in order to direct transmissions in Gerlach's system. Such a memory would have operated in tandem with the processor to store/retrieve data from memory, and the transceiver to make use of the data stored in memory in directing transmissions.

205. Barratt explicitly discloses that its network-based apparatus (base station 1) has “a conventional central processing unit and associated **memory** and programming.” Barratt, 6:59-62. A person having ordinary skill in the art would have found it obvious to incorporate Barratt’s memory into Gerlach to store the weight matrix W' for the reasons discussed in Section X.B.1. A person having ordinary skill in the art would also have found it obvious to incorporate Barratt’s memory into Gerlach to store the weight matrix W' because doing so would have amounted to no more than use of a known technique (Barratt’s memory) to improve similar devices (Gerlach’s network-based apparatus) in the same way (using a memory to store Gerlach’s weight matrix W').

206. Accordingly, in my opinion, the combination of Gerlach and Barratt discloses or suggests a memory in communication (“operatively coupled”) with the transceiver and processor (“to one or more of the processor or the transceiver”) to store matrix W' (“wherein a routing table is stored in the memory”).

6. Claims 2, 13, 23, and 33

- a. “wherein one or more of the processor, the transceiver, or the smart antenna is further configured to: determine a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals”**

207. Claims 2, 13, 23, and 33 are substantively identical, except that claim 2 depends from claim 1, claim 13 from claim 12, claim 23 from claim 22, and claim

33 from claim 32. In my opinion, the combination of Gerlach and Barratt discloses or suggests that “one or more of the processor, the transceiver, or the smart antenna is further configured to: determine a first set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals.”

208. As discussed, above in Section X.B.2.d(i), Gerlach’s system “extract[s] information about the propagation environment from feedback signals 32 generated by transmission of selected probing signals 17” and the information conveyed by these feedback signals 32 is used to determine a new weight matrix W' . Gerlach, 5:4-10. The complex amplitudes that comprise weight matrix W' (e.g., $15(1\dots n, 1)$ - $15(1\dots n, m)$) are provided by weight computer 40 (as shown in Figure 3b below) to transmitting array 12. See Gerlach, Fig. 3b, 3:49-63, 4:24-28 (“This distribution is specified by the set of complex amplitudes $w_{11} \dots w_{nm}$ discussed previously, where for example w_{kj} represents the amplitude and phase with which information signal 19(j) is applied to transmitting element 14(k)”).

209. For example, for information signal 19(1), weight computer 40 provides weights $15(1\dots n, 1)$ to transmitting array. Likewise, for information signal 19(m), weight computer 40 provides weights $15(1\dots n, m)$. The beampattern created through by applying elements of weight matrix W' to an information signal is a “complementary null beampattern.” Gerlach, 5:20-22.

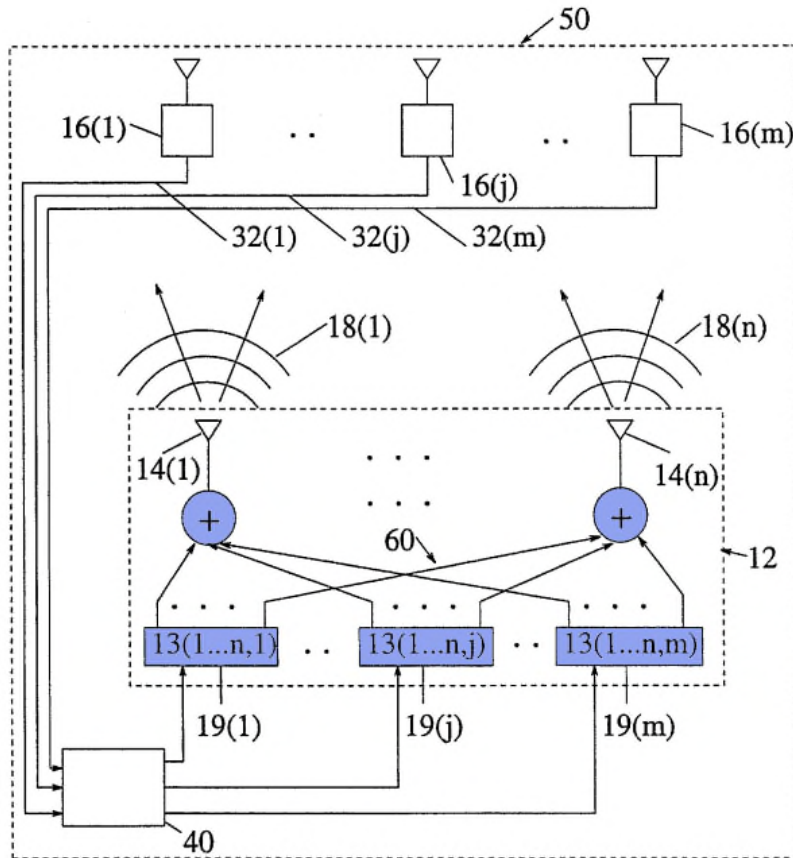


Fig. 3b

Gerlach, Figure 3b (annotated).

210. Accordingly, in my opinion, the combination of Gerlach and Barratt teaches the smart antenna determines a matrix W' (first set of weights), based on which Gerlach places transmission peaks and transmission nulls in spatially distributed patterns of electromagnetic signals.

7. Claims 3, 14, 25, and 34

- a. **“wherein one or more of the processor, the transceiver, or the smart antenna is further configured to: modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals”**

211. Claims 3, 14, 25, and 34 are substantively identical, except that claim 3 depends from claim 1, claim 14 from claim 12, claim 25 from claim 22, and claim 34 from claim 32. In my opinion, the combination of Gerlach and Barratt discloses or suggests that “one or more of the processor, the transceiver, or the smart antenna is further configured to: modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals.”

212. Gerlach recognizes that “changes in the location of receivers 16 or changes in the scattering environment will necessitate periodic reoptimization of complex amplitudes 15 comprising weight matrix W.” Gerlach, 3:14-17. Gerlach “monitor[s] cross-talk during transmission of information signals 19” and initiates a **“redetermination** of weight matrix W” whenever crosstalk increases above a preselected level.” Gerlach, 6:27-31. Gerlach discloses that, alternatively, “weight matrix W can be reoptimized at regular intervals.” Gerlach, 6:31-32. With either of these reoptimization techniques, Gerlach’s methods **“determine the weight matrix**

W that generates complimentary null beampatterns for all signals 19.” Gerlach, 6:32-35. The updated weight values (15(1,1)-15(n,m)) are provided to the transmitting antenna array 12 shown in Fig. 3b. There they are applied to subsequent transmissions of information signals. Thus, weight computer 40 adjusts the weights (complex amplitudes) used in transmitting array 12 which in turn cause modifications to the beampattern generated by the transmitting array.

213. Accordingly, in my opinion, Gerlach teaches the smart antenna transmits information signals in modified complementary null beampatterns (“modify the one or more spatially distributed patterns of electromagnetic signals”) based on adjusting matrix W to determine matrix W’ for placement of transmission peaks and transmission nulls in the transmission signals (“based on adjustment of a first set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals”).

8. Claims 4, 15, and 26

- a. “one or more of the processor, the transceiver, or the smart antenna is further configured to: transmit a third data stream to the first client device via the modified one or more spatially distributed patterns of electromagnetic signals”**

214. Claims 4, 15, and 26 are substantively identical, except that claim 4 depends from claim 3, claim 15 from claim 14, and claim 26 from claim 25. In my opinion, the combination of Gerlach and Barratt discloses or suggests “one or more

of the processor, the transceiver, or the smart antenna is further configured to: transmit a third data stream to the first client device via the modified one or more spatially distributed patterns of electromagnetic signals.”

215. As discussed in Section X.B.7, Gerlach’s system adjusts the weight matrix, W , “to reoptimize” its directed transmission. Accordingly, the adjusted weights are applied to the new information signal 19 to be transmitted to a receiver 16 in the same manner described above in Section X.B.2.d(ii). For example, a new information signal 19(1)’ (“*a third data stream*”) intended for receiver 16 is carried by the “*modified one or more spatially distributed patterns of electromagnetic signals.*”

216. Thus, the combination of Gerlach and Barratt teaches each of the transceiver and smart antenna (“wherein one or more of the processor, the transceiver, or the smart antenna is further configured to:”) transmitting additional information signals 19 (“transmit a third data stream”) to receiver 16(1) (“first client device”) using the modified spatially distributed patterns of electromagnetic signals.

9. Claims 5, 16, 24, and 27

- a. **“wherein one or more of the processor, the transceiver, or the smart antenna is further configured to: determine a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals, wherein the first set of weights and the second set of weights are different.”**

217. Claims 5, 16, 24, and 27 are substantively identical, except that claim 5 depends from claim 3, claim 16 from claim 14, claim 24 from claim 23, and claim 27 from claim 26. In my opinion, the combination of Gerlach and Barratt discloses or suggests that “one or more of the processor, the transceiver, or the smart antenna is further configured to: determine a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals, wherein the first set of weights and the second set of weights are different.”

218. As discussed above in Section X.B.7, with either reoptimization technique disclosed by Gerlach, Gerlach’s methods “**determine the weight matrix W** that generates complimentary null beampatterns for all signals 19.” Gerlach, 6:32-35. The adjusted weight matrix W includes an updated set of weights to reoptimize the directed beams of the system. The updated set of weights in the adjusted weight matrix (“*second set of weights*”) differs from the original set of weights in weight matrix W' as needed to re-optimized the directed beams.

219. A person having ordinary skill in the art would have understood that the propagation environment regularly changes because of a variety of factors, including outside interference, movement of receivers, and changes in topography where the network is located which can lead to increases in cross-talk. When a new weight matrix (matrix W') is calculated (e.g., based on detected increase in cross-talk), a person having ordinary skill in the art would have understood that the new weight matrix would have different weights due to changes in propagation environment.

220. Thus, the combination of Gerlach and Barratt teaches a “the smart antenna” “is further configured to: determine a second set of weights to apply to the one or more spatially distributed patterns of electromagnetic signals, wherein the first set of weights and the second set of weights are different.”

10. Claims 6, 17, 28 and 29

- a. “wherein one or more of the processor, the transceiver, or the smart antenna is further configured to: modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals; and transmit a [third or fourth] data stream to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals.”**

221. Claims 6, 17, and 29 are identical, except that claim 6 depends from claim 3, claim 17 from claim 14, and claim 29 from claim 25. Claim 28 is substantially the same as claim 6, except claim 28 refers to a “fourth data stream” instead of a “third data stream.” In my opinion, Gerlach discloses or suggests a smart antenna configured to “modify the one or more spatially distributed patterns of electromagnetic signals based on adjustment of a second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals.” In addition, in my opinion, Gerlach teaches a smart antenna and transceiver configured to “transmit a third [or fourth] data stream to the second client device via the modified one or more spatially distributed patterns of electromagnetic signals.”

222. As discussed in Section X.B.7, Gerlach teaches continually adjusting the weights of weight matrix W applied to the information signals based on factors such as pre-determined interval or increase in cross-talk. Specifically, Gerlach

discloses or suggests using the smart antenna to adjust a first set of weights (matrix W) to determine a matrix W' , based on which Gerlach modifies transmission peaks and transmission nulls in spatially distributed patterns of electromagnetic signals. In the same way as discussed above, in Section X.B.2.d(iii), the adjusted weights are applied to the new information signal 19 to be transmitted to a receiver 16. For example, subsequent information signals 19(1)' ("a third data stream") and 19(1)" ("a fourth data stream") intended for receiver 16 are carried by the modified "spatially distributed pattern[] of electromagnetic signals." As also discussed in Section X.B.7, the calculations to redetermine the weight matrix W are performed by weight computer 40 which is part of the "smart antenna."

223. Accordingly, Gerlach teaches the smart antenna ("wherein one or more of the processor, the transceiver, or the smart antenna ... is further configured to:") transmits information signals in modified complimentary null beampatterns ("to modify the one or more spatially distributed patterns of electromagnetic signals") based on adjusting matrix W' to determine weight matrix W'' for placement of transmission peaks and transmission nulls in the transmission signals ("based on adjustment of a second set of weights to manipulate the one or more spatially distributed patterns of electromagnetic signals."

224. Also, in my opinion, the combination of Gerlach and Barratt teaches that each of "the transceiver **[and]** the smart antenna" are configured to "transmit a

third data stream via the modified one or more spatially distributed patterns of electromagnetic signals.”.

225. Furthermore, in my opinion, the combination of Gerlach and Barratt also teaches that each of “the transceiver **[and]** the smart antenna” are configured to “transmit a fourth data stream via the modified one or more spatially distributed patterns of electromagnetic signals.”

11. Claims 7 and 18

- a. **“wherein the first feedback information and the second feedback information comprises at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, timing data, or an index to a routing table.”**

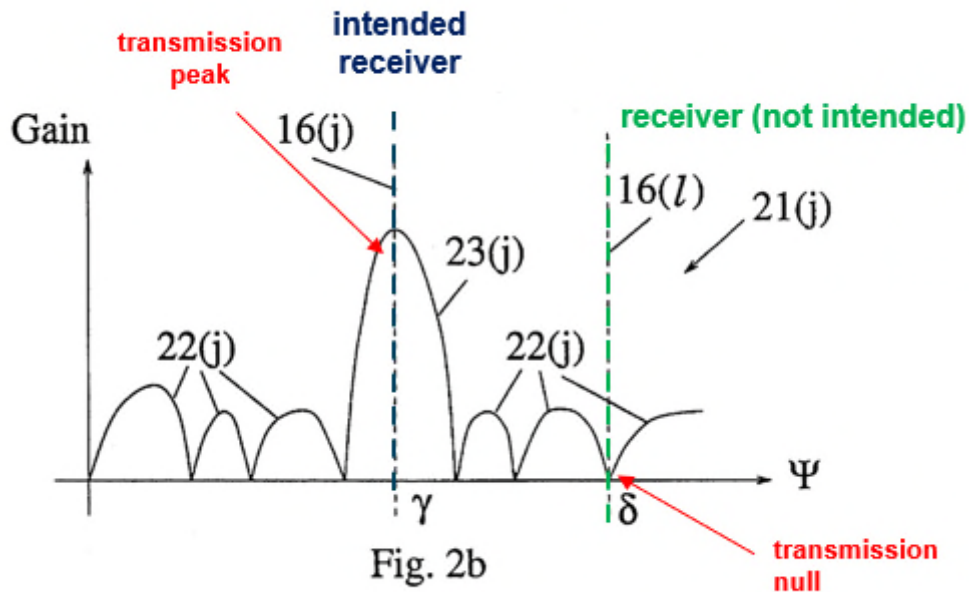
226. Claims 7 and 18 are identical, except claim 7 depends from claim 1 and claim 18 depends from claim 12. For the reasons discussed above in Section X.B.4.a in my opinion, Gerlach teaches “wherein the first feedback information and the second feedback information comprises at least one of: a transmit power level, a data receive rate, an antenna direction, quality of service data, a signal to noise ratio, a phase value, an amplitude value, a frequency value, timing data, or an index to a routing table.” Accordingly, Gerlach teaches that feedback signal 32(l) (“first feedback information”) and feedback signal 32(j) (“second feedback information”) each comprise an index to matrix A (“index to a routing table”).

12. Claims 8 and 9

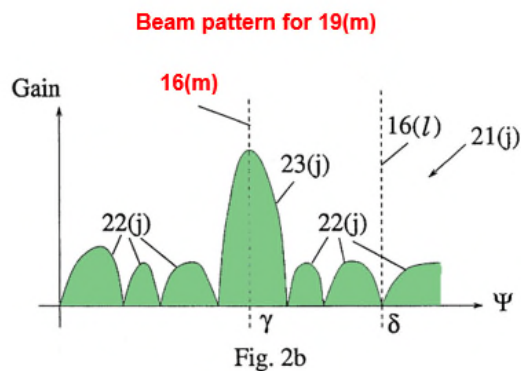
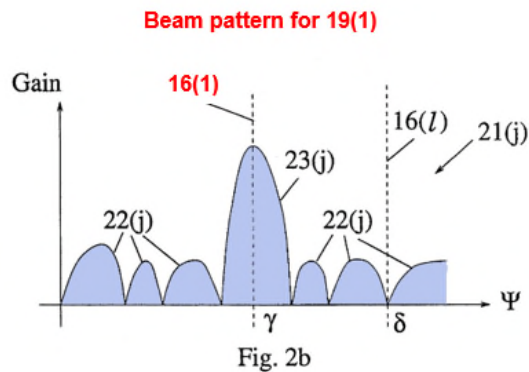
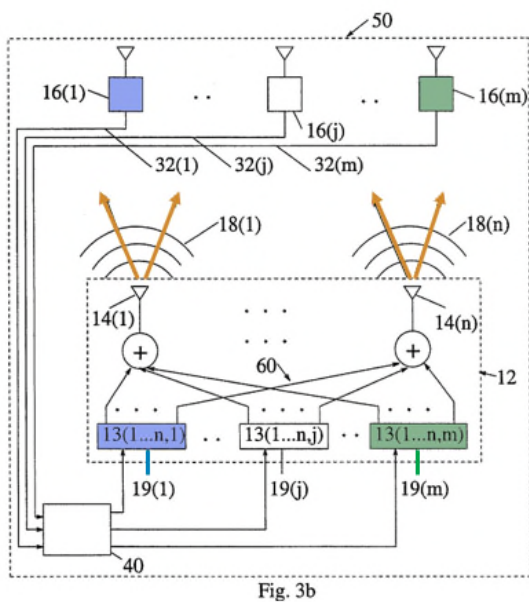
- a. **“wherein the one or more spatially distributed patterns of electromagnetic signals are further configured to exhibit a first transmission null at a location of a [third/fourth] device”**

227. In my opinion, Gerlach teaches “the one or more spatially distributed patterns of electromagnetic signals are further configured to exhibit a first transmission null at a location of a third device” and “the one or more spatially distributed patterns of electromagnetic signals are further configured to exhibit a first transmission null at a location of a fourth device.”

228. As discussed above in Section X.B.2.d(ii), using the adjusted weight matrix W' , transmitting array 12 “generate[s] a complimentary null beam pattern.” Gerlach, 5:20-22. Gerlach explains that, when transmitting an information signal directed to any particular receiver such as receiver 16(j), “[n]ull beampattern 21” has a “primary lobe 23(j) with unit gain at angle γ , in the direction of intended receiver 16(j), and side lobes 22(j) with nulls in the direction of **all remaining receivers** 16(l) where $l \neq j$.” Gerlach, 3:34-39. That is, the beampattern 21 for information signal 19 “exhibit[s] a first transmission peak at a location of the first client device” and “a transmission null” at all other receivers (i.e., “a location of a third device” and “a location of a fourth device”).



229. Specifically, Gerlach discloses that “[e]ach information signal 19 will have its own beampattern 21 generated by interference between transmission signals 18.” Gerlach, 3:20-22. In other word, each of the simultaneously communicated information signals has a beampattern like that shown in Fig. 2b. As shown in the annotated figure below at right, “complimentary null beampattern” 21(1) directed to receiver 16(1) carrying information signal 19(1) (top) and “complimentary null beampattern’ 21(m) directed to receiver 16(m) carrying information signal 19(m) (bottom). Both beampatterns exist when information signals 19(1) and 19(m) are transmitted simultaneously.



Gerlach, Figs. 3b and 2b (annotated).

230. Thus, the beampattern intended for receiver 16(1) would exhibit transmission nulls at the location of **every** receiver that is not 16(1), which Gerlach generically refers to as receivers 16(*l*). As Gerlach notes that its system may have 16(1) to 16(*m*) receivers, Gerlach discloses or suggests at least four receivers (e.g., receiver 16(1) receiving information signal 19(1), receiver 16(*m*) receiving information signal 19(*m*), and at least first and second receivers that are not receivers 16(1) and 16(*m*).

231. Accordingly, Gerlach teaches that the transmission signals (“one or more spatially distributed patterns of electromagnetic signals”) are configured to

exhibit a transmission null at a first receiver that is not receivers 16(1) and 16(m) (“configured to exhibit a first transmission null at a location of a third device”).

232. Likewise, Gerlach teaches that the transmission signals (“one or more spatially distributed patterns of electromagnetic signals”) are configured to exhibit a transmission null at a second receiver that is not receivers 16(1) and 16(m) (“configured to exhibit a second transmission null at a location of a fourth device”).

13. Claim 30

- a. **“a memory, wherein the determination of where to place the transmission peaks and the transmission nulls within one or more spatially distributed patterns of electromagnetic signals is further based partly on information contained within the routing table, wherein the routing table is stored in the memory”**

233. In my opinion, the combination of Gerlach and Barratt discloses or suggests a memory and that “the determination of where to place the transmission peaks and the transmission nulls within one or more spatially distributed patterns of electromagnetic signals is further based partly on information contained within the routing table, wherein the routing table is stored in the memory.” As discussed in Section X.B.5.a, the combination of Gerlach and Barratt discloses or suggests a “*memory*” storing a “*routing table*” (Gerlach’s weight matrix, W).

234. In Gerlach, the determination of the complimentary null beam pattern for an information signal 19 to be transmitted to an intended receiver 16 uses the

weight matrix. As discussed above in Section X.B.5, Gerlach’s system “routes” the directed beam carrying information signal 19(1) to receiver 16(1) and the directed beam carrying information signal 19(m) to receiver 16(m) based on the weights contained in matrix W' (the “routing table”).

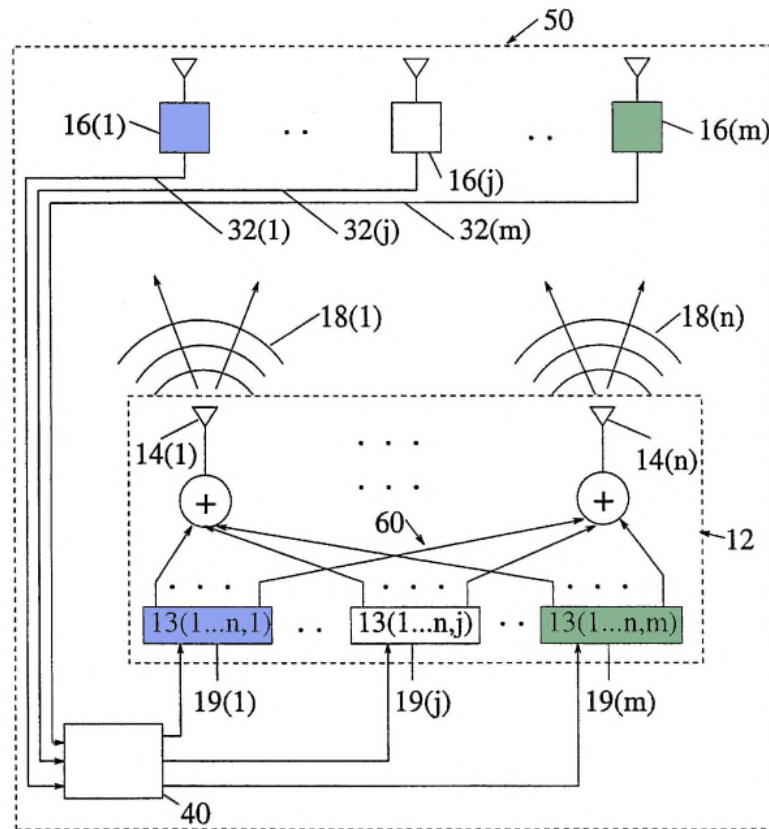


Fig. 3b

Gerlach, Figure 3b (annotated)

235. Accordingly, the combination of Gerlach and Barratt discloses or suggests storing matrix W' (“routing table”) in a memory and using its weights to place transmission peaks and nulls (“determination of where to place the

transmission peaks and transmission nulls”) in spatially distributed patterns of electromagnetic signals.

14. Claim 31

a. “wherein the routing table comprises weighting values.”

236. In my opinion, Gerlach teaches that “the routing table comprises weighting values.” In particular, for the reasons discussed above in Section X.B.4.a, Gerlach teaches that the matrix W' (“routing table”) comprises weighting values.

C. Ground 2: Gerlach, Barratt, and Okamoto Render Obvious Claims 10-11 and 19-21

1. A Person Having Ordinary Skill in the Art Would Have Been Motivated to Combine Gerlach and Barratt with Okamoto

237. As discussed above in Section X.B.1 and throughout this declaration, a person having ordinary skill in the art would have been motivated to combine Gerlach with Barratt. In my opinion, a person having ordinary skill in the art would have been motivated to implement the Gerlach-Barratt SDMA capable network-based apparatus in an IEEE 802.11 (WiFi) network as a base station (access point) as taught by Okamoto.

238. I would first note that, while Gerlach describes the general concept of a wireless communications system, it has a limited description of the implementation details of a wireless network-based apparatus. Gerlach, 1:13, 2:11-12. Moreover,

Gerlach teaches transmission of “information signals” throughout, which a person having ordinary skill in the art would have understood to include data communications signals transmitted over a local area network. Gerlach however does not specifically disclose or limit the type of wireless network (e.g., cellular or WiFi network) in which its system is implemented. Thus, without such a description, a person having ordinary skill in the art would have been motivated to find references describing network deployment options for data communications transmissions and would have been led to Okamoto which discusses the use of SDMA for medium access by an access point in an IEEE 802.11 (WiFi) network. Okamoto further teaches that IEEE 802.11 was a known standard for implementing local area networks. A person having ordinary skill in the art would have recognized the benefits of using Gerlach’s system in a WiFi network as taught by Okamoto because well before the earliest possible priority date of the ’376 patent, IEEE 802.11-compliant networks were rapidly growing in popularity. Gast, at 5, 10; Miller, at 1, Saliga, at 1. In fact, the initial release of the IEEE 802.11 standard was published in 1997, several years before the earliest possible priority date of the ’376 patent. 802.11, 6.

239. A person having ordinary skill in the art would have been further motivated to deploy Gerlach in an IEEE 802.11 (WiFi) network access point to take advantage of the increased capacity and power reduction offered by Gerlach’s

system. As discussed in Section X.B, Gerlach’s network-based apparatus is capable of simultaneously transmitting information signals to multiple receivers. This capability increases the capacity of the system (by increasing the number of devices that can be serviced in a coverage area). A person having ordinary skill in the art would have recognized that increased capacity was highly beneficial for WiFi networks because of the increasing popularity of such networks prior to the ’376 patent, so the need to support more and more users grew. Moreover, by reducing crosstalk, Gerlach’s probing/feedback technique allows the system to transmit information signals with a sharper beam at a higher gain, resulting in reduced cross-talk. Thus, a person having ordinary skill in the art would have recognized that Gerlach’s system increases the range of the network-based apparatus. This allows the system to reach user devices that are at a farther distance from the network apparatus without exceeding the transmission power limit in unlicensed band imposed by the Federal Communications Commission (FCC). Because of the FCC, Part 15 rules, a person having ordinary skill would have been highly motivated to implement techniques such as Gerlach’s technique which kept power down while improving the reach, capacity, and transmission quality of an access point.

240. Furthermore, Okamoto suggests the combination by describing the use of SDMA techniques in IEEE 802.11 networks. Okamoto specifically teaches that 802.11 provides features that “aid the implementation of an SDMA system.”

Okamoto, at 2. A person of ordinary skill in the art would have also recognized that the use of Gerlach's probing/feedback technique would not have required modifications to the IEEE 802.11 protocol. For example, a version of the 802.11 standard that was available prior to the '376 patent provides the format for MAC frames that are transmitted over the network for management or control, or for transmitting data. 802.11, at 50-52. This included "Reserved" (i.e., unused) frame subtypes were available to use for additional transmissions such as channel probing and feedback messages. 802.11, at 52. A person having ordinary skill in the art would have used these reserved frame subtypes to implement the probing and feedback signals of Gerlach. Using the existing frame formats of IEEE 802.11 would have been largely, if not entirely, implemented in software and so would not have required substantial changes to circuitry or hardware. A person having ordinary skill in the art would have found that implementing IEEE 802.11 in this manner to be routine. For these reasons a person having ordinary skill in the art would have had a reasonable expectation of success in the combination.

241. A person having ordinary skill in the art would also have been motivated to use the Gerlach-Barratt SDMA capable wireless network-based apparatus as a base station (access point) in an IEEE 802.11-compliant wireless network. Doing so would have merely been applying a known technique (802.11's network protocols) to a known device (the Gerlach-Barratt SDMA capable network-

based apparatus) ready for improvement to yield predictable results (enabling the Gerlach-Barratt SDMA capable network-based apparatus to be implemented in the increasingly popular and widely deployed 802.11-compliant networks).

2. Claim 10

- a. “wherein the processor, transceiver and smart antenna are part of an access point configured to support the first and second client devices in accordance with an 802.11 standard, and wherein a position of the access point is fixed”**

242. In my opinion, the combination of Gerlach, Barratt, and Okamoto discloses or suggests that “the processor, transceiver and smart antenna are part of an access point configured to support the first and second client devices in accordance with an 802.11 standard, and wherein a position of the access point is fixed.”

243. Okamoto describes a Smart Wireless LAN (SWL) system that “integrates the Space-Division-Multiple-Access (SDMA) technique with the IEEE 802.11 wireless LAN standard.” Okamoto, at 1. Okamoto uses a “base station” having an “M-element uniform linear antenna array.” Okamoto, at 1.

244. A person having ordinary skill in the art would have understood that Okamoto’s “base station” is an 802.11 “access point.” In particular, the 802.11

standard defines an “access point” is “[a]ny entity that has station⁸ functionality and provides access to the distribution services, via the wireless medium (WM) for associated stations.” 802.11, at 19; *see also* Gast, at 13-16 (describing 802.11 system as including a centralized “access point”). Thus, Okamoto’s base station is an “access point.” Thus, the network-based apparatus of Gerlach and Barratt, utilized as an access point as taught by Okamoto, “support[s] the first and second client devices in accordance with an 802.11 standard.”

245. The combination of Gerlach, Barratt, and Okamoto discloses or suggests that the “position of the access point is fixed.” It should be noted that the specification of the ’376 patent does not disclose that an access point is in a fixed position. The only discussion of fixed components is where the ’376 patent states: “Although not required, **access station 102 is typically fixed**, and remote client devices 104 may be fixed or mobile.” ’376 patent, 4:11-13.

246. Gerlach states that “[u]ncertainties in the response of the transmitting antenna array, **the locations of the intended receivers**, and the nature and location

⁸ The 802.11 standard defines a “station” in 802.11 is “any **device** that contains an IEEE 802.11 conformant medium access control (MAC) and physical layer (PHY) interface to the wireless medium (WM)”—in other words a device that conforms with standards so as to access the wireless medium. 802.11, at 21.

of scatterers in the vicinity of the array, limit the information available about the transmission channel.” Gerlach, 1:36-39. Gerlach also mentions that in its probing/feedback technique the “**location of receivers 16** or changes in the scattering environment will necessitate periodic reoptimization of complex amplitudes 15 comprising weight matrix W.” Gerlach, 3:14-17; *see also* Section X.B.2.c(i) above. Notably, Gerlach takes the location of the receivers into account. However, Gerlach does not consider the location of the network-based apparatus. A person having ordinary skill in the art would have understood that Gerlach’s network-based apparatus had fixed position/location. Indeed, by 2002, it was well-known to even a lay person, that network-based apparatus (e.g., wireless access points) in wireless systems were fixed in location.

247. Okamoto, for example, discloses an access point that implements 802.11, which is intended to be “[a] specification for wireless connectivity for *fixed*, portable, and moving stations within a local area.” 802.11, at 17. As I mentioned above, an 802.11 access point is a type of station.

248. Accordingly, in my opinion, the combination of Gerlach, Barratt, and Okamoto discloses or suggests a processor, transceiver, and smart antenna comprising an “access point” configured to support receiver 16(l) (“first client device”) and receiver 16(m) (“second client device”) in accordance with 802.11.

3. Claim 11

a. “wherein the location of the first client device is not within a line of sight of the smart antenna”

249. In my opinion, Gerlach, Barratt, and Okamoto discloses or suggests “the location of the first client device is not within a line of sight of the smart antenna.”

250. As discussed above in section X.B.4.a, Gerlach’s system “extract[s] information about the propagation environment from feedback signals 32 generated by transmission of selected probing signals 17” to determine the weight matrix, W' , used to transmit information signals in a complimentary null beampattern. Among the information that may be taken into account in calculating weight matrix, W' is information about the “propagation environment,” which “includes any scattering bodies located between transmitting elements 14 and receivers 16, as well as any properties of the ambient environment that affect signal transmission.” Gerlach, 4:6-13.

251. A person having ordinary skill in the art would have understood that “scattering bodies” between the smart antenna’s elements 14 and a first client device (receiver 16(1)) would encompass situations where a line of sight is blocked, such as when receiver 16(1) is blocked by a building, a tree, or a piece of furniture from smart antenna 12.

252. Moreover, Okamoto noted that the system was used “[w]hen one user was blocked from the base station while the other user had LOS,” or line of sight. Okamoto, at 3. Thus, the user device is not within a “*line of sight of the smart antenna*.” Based on this disclosure, a person having ordinary skill in the art would have understood that when implementing the combined Gerlach, Barratt, and Okamoto system, the “user” (or client device) may not be within the line of sight of the base station with the smart antenna.

253. Accordingly, in my opinion, the combination of Gerlach, Barratt, and Okamoto discloses or suggests that the location of receiver 16(1) (“location of the first client device”) is outside a line of sight of array 12 (“not within a line of sight of the smart antenna”).

4. Claim 19

a. **“The data-communications networking apparatus as recited in claim 12, configured for a wireless local area network”**

254. In my opinion, the combination of Gerlach, Barratt, and Okamoto discloses or suggests that the “data-communications networking apparatus” is “configured for a wireless local area network.”

255. In particular, Gerlach describes an arrangement applicable to general “wireless communication systems.” Gerlach, 1:13, 2:11-12. There is no suggestion in Gerlach that its system and techniques are limited to any particular specific use

case. A person having ordinary skill in the art would have understood that Gerlach’s disclosure of “information signals” throughout would have understood to include data communications signals transmitted over a wireless local area network.

256. Okamoto describes a “technique with the IEEE 802.11 wireless **LAN** standard to enable multiple users to transmit on a wireless **LAN** at the same time in the same frequency bank.” Okamoto, at 1. A person having ordinary skill in the art would have understood that a wireless LAN is a wireless **l**ocal **a**rea **n**etwork.

257. Accordingly, the combination of Gerlach, Barratt, and Okamoto discloses or suggests an apparatus configured for use in a wireless communication system (“configured for a wireless local area network”).

5. Claim 20

a. “wherein a position of the smart antenna is fixed”

258. In my opinion, the combination of Gerlach, Barratt, and Okamoto discloses or suggests that “a position of the smart antenna is fixed.” As discussed above in Section X.C.2, the combination of Gerlach, Barratt, and Okamoto teaches or at least suggests that the position of the apparatus containing the “*smart antenna is fixed*” for the reasons discussed in Section X.C.2.

259. As discussed above in Section X.B.2.b(ii), the “*smart antenna*” is a component of the transmitting array. These components, which are an integral part of the transmitting array, are not moveable from the other components of the

transmitting array since these components must operate in a state without changing the transmission characteristics provided by the receiver feedback. If the smart antenna apparatus were movable, then transmission characteristics of the smart antenna would change, as the antenna elements moved relative to the receivers. Such change would have to require a re-start of the probing, feedback, and weight optimization process. Thus, the “*position of the smart antenna*” in the network-based apparatus of Gerlach “*is fixed.*”

260. Accordingly, in my opinion, combination of Gerlach, Barratt, and Okamoto discloses or suggests a fixed position for the smart antenna.

6. Claim 21

a. “configured to support the first and second client devices in accordance with an IEEE 802.11 standard”

261. For the reasons discussed above in Section X.C.2, in my opinion, the combination of Gerlach, Barratt, and Okamoto discloses or suggests an apparatus “configured to support the first and second client devices in accordance with an IEEE 802.11 standard.”

XI. CONCLUSION

262. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so mare are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code.

Dated: March 3, 2022

 Digitally signed
by Zhi Ding
Date: 2022.03.03
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Zhi Ding, Ph.D.