IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Aldana et al.		
U.S. Patent No.:	8,416,862	Attorney Docket No.:	50095-0050IP1
Issue Date:	April 9, 2013		
Appl. Serial No.:	11/237,341		
Filing Date:	September 28, 2005		
Title:	EFFICIENT FEEDBACK OF CHANNEL INFORMATION IN A CLOSED LOOP BEAMFORMING WIRELESS COMMUNICATION SYSTEM		

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PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT NO. 8,416,862 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42

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EX1021 Declaration of Jacob Munford

LISTING OF CHALLENGED CLAIMS

CLAIM	LIMITATION
[1.P]	A method for feeding back transmitter beamforming information from a receiving wireless communication device to a transmitting wireless communication device, the method comprising:
[1.a]	the receiving wireless communication device receiving a preamble sequence from the transmitting wireless device;
[1.b]	the receiving wireless device estimating a channel response based upon the preamble sequence;
[1.c]	the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);
[1.d]	the receiving wireless device decomposing the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and
[1.e]	the receiving wireless device wirelessly sending the transmitter beamforming information to the transmitting wireless device.
[2]	The method of claim 1 wherein the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U) comprises: the receiving wireless device producing the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and the receiving wireless device converting the estimated transmitter beamforming unitary matrix (V) to polar coordinates.
[3]	The method of claim 1 wherein the channel response (H), estimated transmitter beamforming unitary matrix (V), and the receiver beamforming unitary matrix (U) are related by the equation: $H=UDV^*$ where, D is a diagonal matrix.

CLAIM	LIMITATION
[4]	The method of claim 3, wherein the receiving wireless device determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U) comprises performing a Singular Value Decomposition (SVD) operation.
[7]	The method of claim 1, wherein: the transmitting wireless device transmits on N antennas; and the receiving wireless device receives on M antennas.
[8]	The method of claim 1, wherein at least one of the transmitting wireless device and the receiving wireless device supports Multiple Input Multiple Output (MIMO) operations.
[9.P]	A wireless communication device, comprising:
[9.a]	a plurality of Radio Frequency (RF) components operable to receive an RF signal and to convert the RF signal to a baseband signal; and
[9.b]	a baseband processing module operable to:
[9.c]	receive a preamble sequence carried by the baseband signal;
[9.d]	estimate a channel response based upon the preamble sequence;
[9.e]	determine an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U);
[9.f]	decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and
[9.g]	form a baseband signal employed by the plurality of RF components to wirelessly send the transmitter beamforming information to the transmitting wireless device.

CLAIM	LIMITATION
[10]	The wireless communication device of claim 9, wherein in determining an estimated transmitter beamforming unitary matrix (V) based upon the channel response and a receiver beamforming unitary matrix (U), the baseband processing module is operable to: produce the estimated transmitter beamforming unitary matrix (V) in Cartesian coordinates; and convert the estimated transmitter beamforming unitary matrix (V) to polar coordinates.
[11]	The wireless communication device of claim 9, wherein the channel response (H), estimated transmitter beamforming unitary matrix (V), and the receiver beamforming unitary matrix (U) are related by the equation: H=UDV* where, D is a diagonal matrix.
[12]	The wireless communication device of claim 9, wherein in determining the estimated transmitter beamforming unitary matrix (V) based upon the channel response and the receiver beamforming unitary matrix (U), the baseband processing module performs Singular Value Decomposition (SVD) operations.
[15]	The wireless communication device of claim 10, wherein: the transmitting wireless device transmits on N antennas; and the wireless communication device includes M antennas.
[16]	The wireless communication device of claim 10, wherein the wireless communication device supports Multiple Input Multiple Output (MIMO) operations.
[17.P]	A method for feeding back transmitter beamforming information from a receiving wireless communication device to a transmitting wireless communication device, the method comprising:
[17.a]	the receiving wireless communication device receiving a preamble sequence from the transmitting wireless device;
[17.b]	the receiving wireless device estimating a channel response based upon the preamble sequence;

CLAIM	LIMITATION
[17.c]	the receiving wireless device decomposing the channel response based upon the channel response and a receiver beamforming unitary matrix (U) to produce an estimated transmitter beamforming unitary matrix (V);
[17.d]	the receiving wireless device decomposing the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information; and
[17.e]	the receiving wireless device wirelessly sending the transmitter beamforming information to the transmitting wireless device.
[18]	The method of claim 17, wherein the receiving wireless device decomposing the channel response based upon the channel response and a receiver beamforming unitary matrix (U) to produce an estimated transmitter beamforming unitary matrix (V) includes performing a Singular Value Decomposition (SVD) operation.

I. INTRODUCTION

Apple Inc. ("Apple" or "Petitioner") petitions for *Inter Partes* Review ("IPR") of claims 1-4, 7-12, and 15-18 ("Challenged Claims") of U.S. Patent 8,416,862 ("the '862 patent"). The '862 patent describes wirelessly "feeding back transmitter beamforming information" from a receiving device to a transmitting device. EX1001, Abstract. The claims recite conventional devices and methods at the time of the alleged priority date—certainly not an innovative achievement. Grounds 1-5 raise prior art combinations presented in IPR2020-00108 ('108 IPR) filed and instituted with a different Petitioner against only claims 9-12 but settled before reaching a final written decision. If these prior art combinations had been before the Office during examination, the '862 patent never would have issued. Petitioner requests the Board institute IPR of the Challenged Claims.

II. MANDATORY NOTICES UNDER 37 C.F.R. §42.8

A. Real Parties-In-Interest Under 37 C.F.R. §42.8(b)(1)

Apple Inc. is the real party-in-interest. No other parties had access to, control over, or funded the present Petition.

B. Related Matters Under 37 C.F.R. §42.8(b)(2)

Bell Northern Research, LLC ("BNR")—the alleged Patent Owner—filed a complaint on August 11, 2021, in the U.S. District Court for the Western District of Texas (Case 6:21-cv-00833-ADA) against Apple Inc. asserting ten patents, including the '862 patent, and served the complaint on August 13, 2021.

BNR also filed complaints in the Southern District of California alleging infringement of the ’862 patent by other parties: Coolpad Technologies, Inc. and Yulong Computer Communications (3:18-cv-1783); Huawei Technologies Co., Ltd., Huawei Device (Hong Kong) Co., Ltd., and Huawei Device USA, Inc. (3:18-cv-01784); Kyocera Corporation and Kyocera International Inc. (3:18-cv-1785); ZTE Corporation, ZTE (USA) Inc., and ZTE (TX) Inc. (3:18-cv-1786); and LG Electronics, Inc., LG Electronics U.S.A., Inc., and LG Electronics Mobile Research U.S.A., LLC (collectively, “LGE”) (3:18-cv-02864-LAB-LL). BNR also filed a complaint in the USITC (Inv. No. 337-TA-3568) alleging infringement of the ’862 patent against a number of other parties. Petitioner is not a real party-in-interest to any of these above-listed proceedings. None of the parties in these proceedings is a real party-in-interest in the proceedings involving Petitioner or in privity with Petitioner.

C. Lead And Back-Up Counsel Under 37 C.F.R. §42.8(b)(3)

Petitioner provides the following designation of counsel.

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D. Service Information

Please address all correspondence and service to the address listed above. Petitioner consents to electronic service by email at IPR50095-0050IP1@fr.com (referencing No. 50095-0050IP1) and cc'ing PTABInbound@fr.com, axf-ptab@fr.com, riffe@fr.com, and hoff@fr.com.

III. PAYMENT OF FEES – 37 C.F.R. §42.103

Petitioner authorizes the Office to charge Deposit Account No. 06-1050 for the petition fee set in 37 C.F.R. §42.15(a) and for any other required fees.

IV. REQUIREMENTS FOR IPR UNDER 37 C.F.R. § 42.104

A. Standing Under 37 C.F.R. § 42.104(a)

Petitioner certifies that the '862 patent is available for IPR and that Petitioner is not barred or estopped from requesting IPR.

B. Challenge Under 37 C.F.R. § 42.104(b) and Relief Requested

Petitioner requests IPR of the Challenged Claims on the grounds below, and requests that the Challenged Claims be found unpatentable. In support, this petition includes a declaration of Dr. Jonathan Wells (EX1003).

Ground	'862 Patent Claims	Basis for Rejection
1	1-4, 7-12, 15-18	§103 – Li-748 (EX1004) in view of Tong (EX1005) and Mao (EX1006)
2	1-4, 7-12, 15-18	§103 – Tong in view of Mao
3	1, 3-4, 7-9, 11-12, 15-18	§103 – Li-054 (EX1007) in view of Mao
4	2, 10	§103 – Li-054 in view of Mao and Yang (EX1008)
5	1, 3-4, 7-9, 11-12, 15-18	§103 – Poon (EX1009) in view of Mao

V. SUMMARY OF THE '862 PATENT

A. Background

The '862 patent describes typical wireless transceivers were "coupled to the antenna" and included a low noise amplifier, and intermediate frequency, filtering, and data recovery stages. EX1001, 1:60-67; 2:1-10 (conventional conversion of "the amplified RF signal into baseband signals"). The '862 patent acknowledges such transceivers traditionally incorporated beamforming, "a processing technique to create a focused antenna beam by shifting a signal in time or in phase to provide gain of the signal in a desired direction to attenuate the signal in other directions." *Id.*, 2:66-3:4. The '862 patent explains that "[i]n order for a transmitter to properly implement beamforming (i.e., determine the beamforming matrix [V]), it needs to know properties of the channel over which the wireless communication is conveyed," so the "receiver must provide feedback information for the transmitter to determine the properties of the channel." *Id.*, 3:14-19; EX1003, ¶28. The receiver may send feedback to the transmitter by "determin[ing] a channel response (H)" and providing it "as the feedback information." EX1001, 3:19-22; EX1003, ¶28. This methodology was known to result in feedback data packs that were "so large that, during the time it takes to send it to the transmitter, the response of the channel has changed." EX1001, 3:22-25. To reduce feedback size, conventional receivers "decompose[d] the channel using singular value decomposition ("SVD") and sen[t] information relating only to a calculated value of the transmitter's beamforming matrix (V) as the feedback information." *Id.*, 3:26-30; EX1003, ¶28. To reduce feedback size, a conventional practice was for the receiver to calculate the matrix V based on H=UDV*,[1] where H is the channel response matrix, D is a diagonal matrix, and U is a receiver unitary matrix, and only send information about matrix V. EX1003, 3:30-33; EX1003, ¶28.

According to the ’862 patent, “[w]hile this approach reduces the size of the feedback information, its size is still an issue for a MIMO wireless communication.” *Id.*, 3:33-35. The ’862 patent alleged “a need” existed “for reducing beamforming feedback information for wireless communications” (col. 3:49-51), but this allegation ignored the state of the art at that time. EX1003, ¶28.

B. Brief Description

The ’862 patent describes a wireless communication system 10 including a plurality of base stations 12, 16, wireless communication devices 18-32, and a network hardware component 34. EX1001, FIG. 1, 4:24-27. These base stations are coupled to the network hardware 34, which “provides the base station … with con-

[1] Each of the matrices H, U, D (also referred to as Σ), and V were referred to by various terminology in the art and the ’862 patent. While the colloquial terms for each of the matrices might have varied, a POSITA would have understood that they each identified the same respective matrix in this common equation. EX1003, ¶[¶53-56.

nectivity to other devices within the system." *Id.*, 4:46-52. Each of the base stations antenna(s) to "communicate with the wireless communication devices." *Id.*, 4:52-55.

The '862 patent illustrates a wireless communication device that includes a host device 18-32 and a radio 60. *Id.*, FIG. 3, 7:21-27. The host device includes "a processing module 50, memory 52, [and] radio interface 54." *Id.*, 7:28-30. The radio interface "allows data to be received from and sent to the radio," "provides the data to the processing module 50 for further processing," and "provides data from the processing module 50 to the radio 60." *Id.*, 7:36-40, 7:43-44.

As shown in Figure 3, the radio includes "a baseband processing module 100, memory 65, a plurality of radio frequency (RF) transmitters 106-110, a transmit/receive (T/R) module 114, a plurality of antennas 81-85, [and] a plurality of RF receivers 118-120." *Id.*, 7:51-56. The baseband processing module and operational instructions stored in memory 65 execute digital receiver/transmitter functions, including, for example "digital intermediate frequency to baseband conversion." *Id.*, 7:56-64.

The baseband processing module is "implemented using one or more processing devices," which "may be a microprocessor, micro-controller, … digital circuitry," and the like. *Id.*, 8:1-9. In operation, in the receive mode, the "baseband processing module 100, based on the mode selection signal 102 produces one or more outbound symbol streams 104 from the outbound data 94." *Id.*, 8:46-48. It further "converts the inbound symbol streams 124 into inbound data 92, which is provided to the host device 18-32." *Id.*, 9:9-12.

Figure 7 of the '862 patent discloses providing beamforming feedback information from a receiver to a transmitter, which "addresses the feed back of observed transmitter beamforming information from a receiving wireless communication device to a transmitting wireless communication device." *Id.*, 13:25-32; FIG. 7. The '862 patent specifically admits that the steps of Figure 7 are "typically performed by a baseband processing module" of a receiving wireless device. *Id.*, 13:25-35; FIG. 7.

The '862 patent states that the method includes a number of conventional steps, including receiving a preamble and estimating a channel response H at the receiver 702, and estimating the transmitter beamforming matrix V based on the channel response H and the receiver beamforming unitary matrix U at 704. *Id.*, 13:36-47. The '862 patent explains that the "channel response (H), estimated transmitter beamforming unitary matrix (V), and the known receiver beamforming unitary matrix (U) are related" by a well-known singular value decomposition (SVD) equation: "H=UDV*, where, D is a diagonal matrix," to determine the estimated transmitter beamforming unitary matrix (V). *Id.*, 13:47-53; EX1003, ¶¶28, 39, 53.

To purportedly address the need to reduce beamforming feedback information, the '862 patent proposed a solution that was already known—decomposing the estimated transmitter beamforming unitary matrix (V) using, for example, a "Givens Rotation." *Id.*, 13:58-67; EX1003, ¶39. The '862 patent explains that if a Givens Rotation is used, "the coefficients of the Givens Rotation and the phase matrix coefficients serve as the transmitter beamforming information that is sent from" the receiver to the transmitter. EX1001, 15:34-38. The transmitter beamforming information are the products of the Givens Rotation ("the set of angles … are reduced"). *Id.*, 13:63-14:3; *see also* 14:34-36; EX1003, ¶39. Using these techniques, "the feedback of transmitter beamforming information" requires less data. *Id.*, 15:59-61. However, as explained in Grounds 1-5 of this Petition, such a solution was plainly suggested in prior art publications, including a disclosure of using a "Givens Rotation" in the same manner.

C. Prosecution History

The '862 patent was filed with 20 claims, which were all rejected as obvious based on at least US 2002/0187753 (Kim) and US 2004/0042558 to (Hwang) EX1002, 176-219, 153-164. The original 20 were allowed and issued without amendment after the after the PTAB reversed these rejections on appeal. *Id.*, 22-46.

D. Critical Date

The evidence here demonstrates that the Challenged Claims require at least one feature that was never contemplated in the earlier priority '451 provisional (filed April 21, 2005) or the '793 application (filed June 28, 2005). EX1003, ¶¶48-50. Specifically, the independent claims require "decompos[ing] the estimated transmitter beamforming unitary matrix (V)." . The '451 provisional and the '793 application are both silent with respect to decomposing matrix V. EX1003, ¶49; *see, generally* EX1010, EX1014. To the extent any of the earlier applications provide support for this element, only the later-filed '686 provisional application on July 13, 2005 would arguably provide a first disclosure of this claim requirement. EX1003, ¶50; EX1011, 22:3-5.

Regardless, even if the claims of the '862 patent were entitled to the '451 provisional date of April 21, 2005, the prior art publications cited in this Petition also predate April 21, 2005.

E. POSITA Definition

For purposes of this IPR, Petitioner submits that a person of ordinary skill in the art at the time of the alleged invention (a "POSITA") would have had Bachelor's degree in Electrical Engineering, Computer Engineering, Computer Science, or a related field, and at least 2-4 years of experience in the field of wireless communication, or a person with equivalent education, work, or experience in this field. EX1003, ¶23.

VI. CLAIM CONSTRUCTION UNDER 37 C.F.R. §§ 42.104(b)(3)

All claim terms should be construed according to the *Phillips* standard. *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005); 37 C.F.R. § 42.100. BNR and other parties submitted briefing on claim construction issues in another district court litigation. EX1017, EX1018. A *Markman* hearing was held in that other litigation on June 19-20, 2019.[2] *See* EX1020. While as summarized below one party to that litigation argued that two claim terms required construction, the Court ultimately indicated that no such constructions for the ’862 patent claims were required under the *Phillips* standard because the plain and ordinary meaning of the claim language was recognizable without adoption of any formal construction. EX1020, 104:23-107:3-9 and 111:4-114:22.

Here, the prior art grounds fall within the scope of the claims regardless of whether a proposed formal construction is adopted.

A. “a baseband processing module operable to…”

[2] The Court has issued a claim construction order (EX1022).

One of the parties to prior litigations argued that this term should be interpreted under §112, ¶6, but the Court explained that, according to the *Phillips* standard, it was not a means-plus-function element. EX1020, 107:10-109:25, 114:24-115:15, 116:11-17; EX1019, 17:13-23:15. Specifically, the Court agreed with BNR that "a baseband processing module" was a known and recognizable structure, so the term was not subject to §112, ¶6. EX1020, 111:4-114:22; 116:18-118:5.

If the Board were to decide this claim phrase is a means-plus-function element, this Petition satisfies 37 CFR §42.104(b)(3) by identifying columns 7-8 as the "specific portions of the specification that describe the structure" corresponding to the recited baseband processing. EX1001, 7:56-59 ("baseband processing module 100, in combination with operational instructions stored in memory 65, executes digital receiver functions and digital transmitter functions"), 8:1-3. The evidence here confirms significant overlap between the preferred embodiment of the '862 patent and each of the Li-748, Tong, Li-054, and Poon references. *Infra*, Sections VII-IX, XI. Regardless of whether this term is subject to §112, ¶6, Grounds 1-5 set forth why this element was provided in the prior art publications. *See* EX1020, 111:4-10 (BNR admitting this element "essentially was well known in the art and its actual operation was well known").

B. "decompose the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information"

One of the parties to the previous litigations argued that this term should be construed as "factor the estimated transmitter beamforming unitary matrix (V) to produce a reduced number of quantized coefficients" (EX1017, 26-30), and that party cited to cols. 4:15-20, 9:59-62, 10:2-6, 10:38-60, 13:65-14:3, 14:31-37, and 14:63-15:8 and the Abstract of the '862 patent to show why this construction was consistent with the specification's description of using a "Givens rotation" for the decompose operation. *See* EX1017, 27:11-29:3. The Court ultimately indicated that no construction was required because the plain and ordinary meaning was recognizable without adoption of any formal construction. EX1020, 104:23-105:2, 106:20-25, 107:3-9 ("Assume the Court will not construe that claim any further, that that language of 'transmitter beamforming information' is what it is and that a person of skill in the art would understand that is the result of the decomposition of the estimated transmitter beamforming matrix").

To the extent that it is interpreted in this manner as indicated by the Court, Petitioner notes that Grounds 1-5 fall within the scope of this "decompose" operation. Alternatively, even if the Board disagreed with the other Court's determination (and applies the party's construction set forth above), Petitioner notes that the prior art in Grounds 1-2 fall within the scope of this "decompose" operation because the prior art provides the same type of "Givens rotation" mentioned in the '862 patent. EX1001, 13:58-67 ("Givens Rotation").

VII. GROUND 1: CLAIMS 1-4, 7-12, 15-18 ARE OBVIOUS IN VIEW OF LI-748, TONG, AND MAO

A. Overview of Li-748

Li-748 discloses a "closed loop MIMO system" that reduces feedback bandwidth "by representing a beamforming matrix using orthogonal generator matrices." *Id.*, Abstract. With reference to Figure 1 (below), Li-748 teaches stations 102, 104, which are "part of a wireless local area network" and "include multiple antennas." *Id.*, 1:50-52, 2:6.

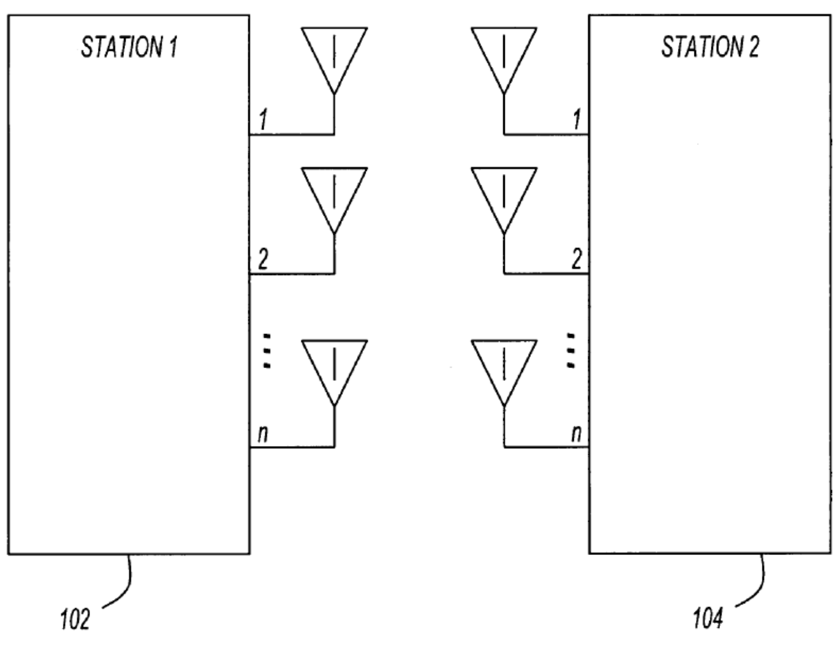


FIG. 1

Id., FIG. 1.

Figure 4 (below) shows a system that "may be a station capable of representing beamforming matrices." *Id.*, 9:36-40. The system 400 "sends and receives signals using antennas 410, and the signals are processed by the various elements shown in FIG. 4." *Id.*, 9:55-57. It includes a physical layer (430) "coupled to antennas 410 to interact with a wireless network" and includes "circuitry to support the transmission and reception of radio frequency (RF) signals," such as "an RF receiver to receive signals and perform 'front end' processing." *Id.*, 9:55-10:1. The system also includes a processor 460 that "reads instructions and data from memory 470 and performs actions in response thereto." *Id.*, 10:7-17.

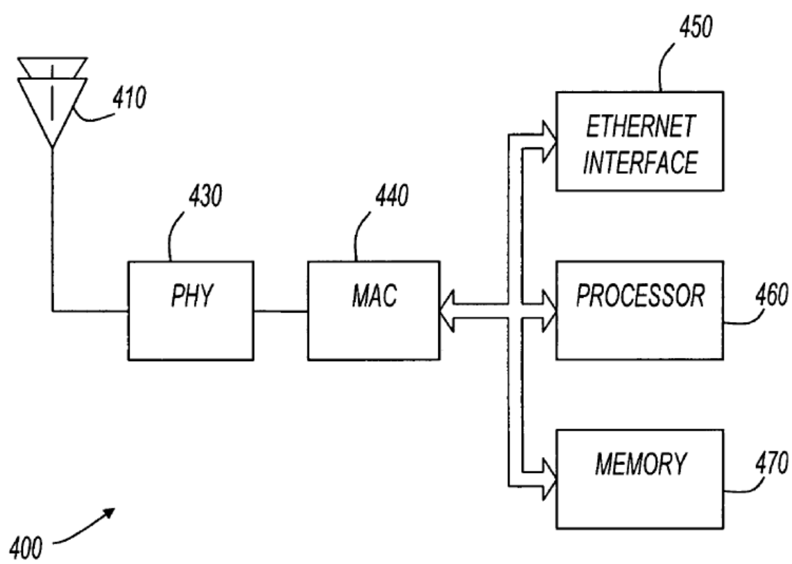


FIG. 4

Id., FIG. 4.

In "closed loop systems, communications bandwidth is utilized to transmit current channel state information between stations, thereby reducing the necessary decoding complexity." *Id.*, 2:44-47. "The current channel state information may be represented by … unitary beamforming matrix V determined using a singular value decomposition (SVD) algorithm." *Id.*, 2:52-54. The "receiver sends each element of the unitary matrix V back to the transmitter." *Id.*, 2:57-59.

Li-748 discloses that a "transmit beamforming matrix may be found using SVD," using the equations H=UDV' and x=Vd, "where d is the n-vector of code bits for n data streams; x is the transmitted signal vector on the antennas; H is the channel matrix; H's singular value decomposition is H=UDV'; U and V are unitary; D is a diagonal matrix[.]" *Id.*, 3:19-32. Li-748 states that to "obtain V at the transmitter, the transmitter may send training symbols to the receiver; the receiver may evaluate H, compute the matrix V'; and the receiver may feedback parameters representing V to the transmitter." *Id.*, 3:32-35.

Li-748 further teaches feedback bandwidth is reduced because "the beamforming matrix V is represented by" fewer real numbers. *Id.*, 2:63-67.

B. Overview of Tong

Tong claims priority to provisional applications that predate the provisional applications of the '862 patent. *Id.* Tong qualifies as prior art under §102(e) based on its June 22, 2005 filing (before Critical Date July 13, 2005), and Tong additionally qualifies as prior art under §102(e) based on its provisional priority date of October 15, 2004. *See Dynamic Drinkware, LLC, v. National Graphics, Inc.*, 800

F.3d 1375 (Fed. Cir. 2015). Under *Dynamic Drinkware*, at least Tong's Provisional application No. 60/614,621 ("'621 Provisional"), filed September 30, 2004, provides clear and unambiguous support for claim 1 of Tong. EX1003, ¶206. The following table identifies exemplary support in the '621 Provisional for each limitation of Tong's claim 1; the testimony of Dr. Wells confirms this fact:

Tong (Claim 1) (EX1005)	**Exemplary Support ('621 Prov.) (EX1012)**
1. A MIMO system comprising:	4:2-5, FIGs. 1-2, 7, 8, 12, 16, 29
a transmitter having multiple transmit antennas;	15:3-4, 15:14-15, 15:27-28, FIGs. 7, 8, 12, 16, 29
at least one receiver, each receiver having at least one receive antenna;	15:3, 15:9-12, 15:15, 15:21-25, 15:28, FIGs. 7-8, 12, 16, 29
each receiver being adapted to transmit at least one type of feedback information selected from a group consisting of: information for use in performing beam-forming; antenna selection/grouping information.	15:9-11, 15:21-25, FIGs. 16, 29

EX1003, ¶206. Additionally, the evidence confirms that at least the '621 Provisional and another of Tong's provisional applications (Provisional application No.

60/619,461 ("'461 Provisional"))—both filed in 2004—provide written description support for all aspects of Tong cited in this petition. *See* EX1003, ¶207.

Tong discloses "[s]ystems and methods for closed loop MIMO (multiple input and multiple output) wireless communication." EX1005, Abstract. With reference to Figure 1 (below), Tong discloses "a base station controller (BSC) 10 which controls wireless communications within multiple cells 12," including base stations 14 and mobile terminals 16.

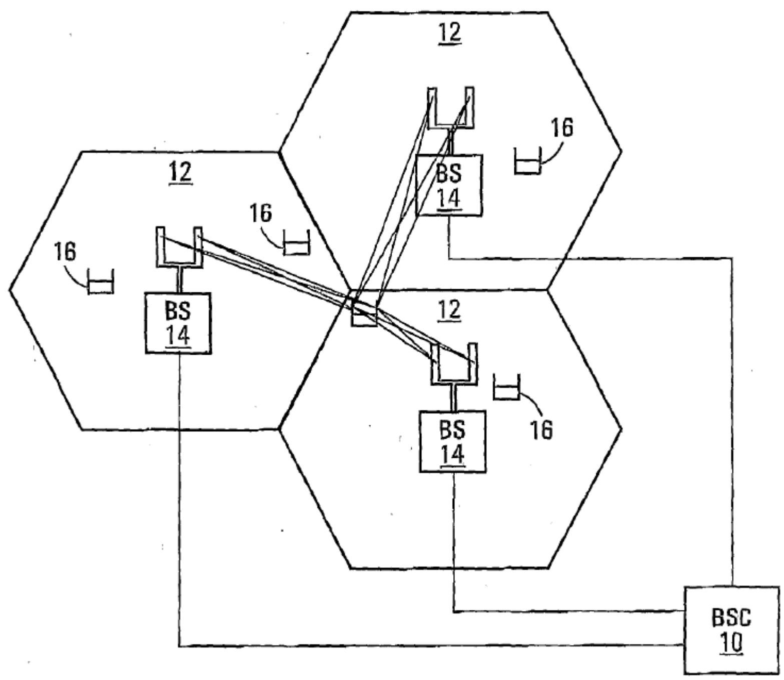


FIG. 1

Id., FIG. 1.

Figure 3 (below) shows a high level overview of a mobile terminal 16 with "a control system 32, a baseband processor 34, transmit circuitry 36, receive circuitry 38, multiple antennas 40, and a network interface 42." *Id.*, [0077]. "The receive circuitry 38 receives radio frequency signals bearing information from one or more base stations 14." *Id.* "Downconversion and digitization circuitry" are used to "downconvert the filtered, received signal to an intermediate or baseband frequency signal." *Id.*

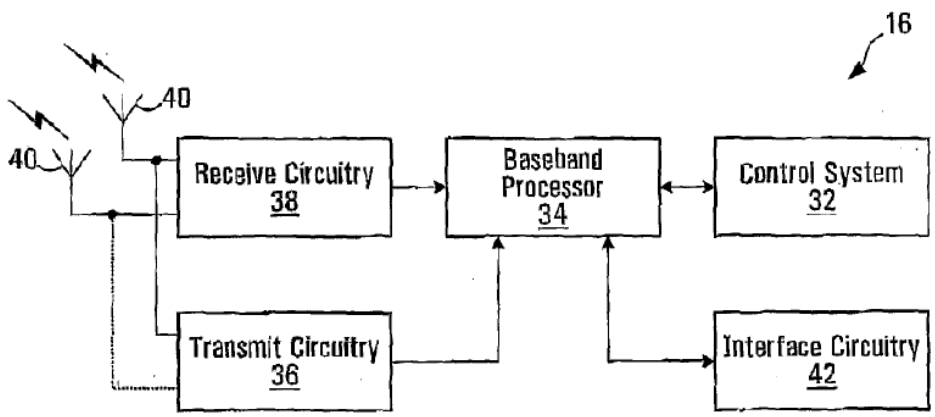


FIG. 3

Id., FIG. 3.

Figure 43 (below) of Tong shows a "block diagram of a system employing an SVD based Givens transform feedback." *Id.*, [0066]. A "receiver" receives signals using its "receive antennas 324" and performs a "channel measurement" at 326, which produces the channel matrix H. *Id.*, [0223]. An SVD is performed on the channel matrix H at 328. *Id.* "[T]he V matrix is decomposed by the Givens transform 330 to produce a series of matrices," each of which can be "uniquely represented by two parameters Θ and C." *Id.* This data is "fed back [to a transmitter] over the MIMO feedback channel 336." *Id.*, [0224].

Tong discloses that, advantageously, "[b]y decomposing the SVD-based unitary V matrix into Givens matrices, the V matrix can be represented by n^2-n independent complex parameters." *Id.*, [0227].

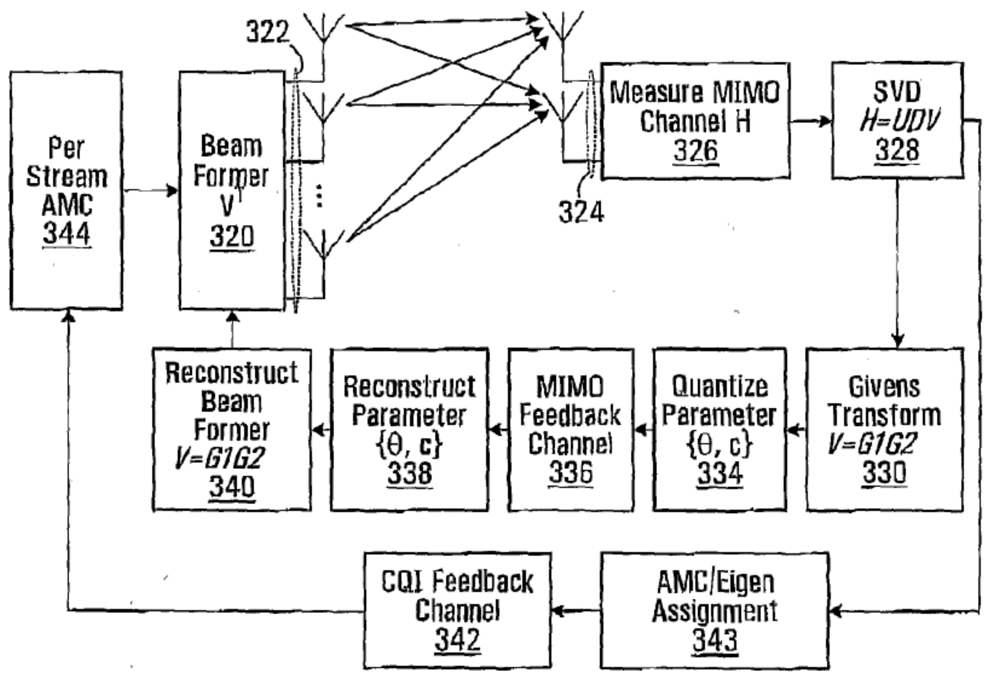


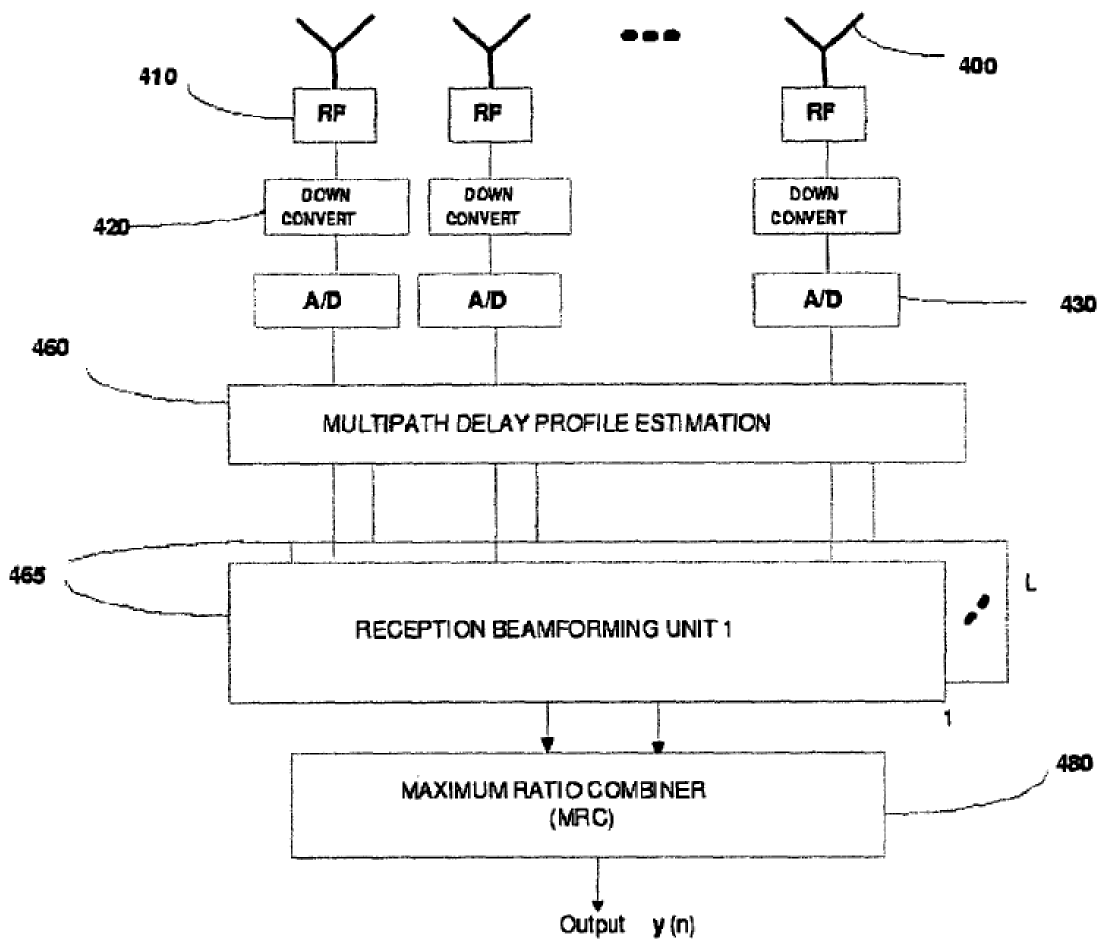
FIG. 43

Id., FIG. 43.

C. Overview of Mao

Mao discloses an "adaptive beam-forming system" in "wireless communication systems." *Id.*, Abstract. Figure 1 (below) shows "a receiver beam-forming system" with "antenna elements 400" that "feed[] into a plurality of RF units 410 and down converters 420." *Id.*, 7:34-42. The system includes A/D units 430, a multipath delay profile estimation unit 460, and beam-forming units 465. *Id.*, 7:42-57.

FIG. 1



Id., FIG. 1.

Mao discloses that its wireless communication system includes "a plurality of antenna elements that receive and transmit radio-frequency signals, one or more radio-frequency units and frequency converters configured to transform received RF signals to receive analog base-band signals and transform analog transmit base-band signals into a transmit RF signals." *Id.*, 3:28-36.

D. Obviousness in view of Li-748, Tong, and Mao

As explained above, Li-748 discloses a wireless station that operates in a wireless network and sends and receives data. EX1004, 9:55-10:1. Li-748 further discloses evaluating a channel matrix based on training symbols received from a transmitter, performing an SVD on the channel matrix to determine a transmit beamforming matrix V, and transmitting matrix V back to the transmitter. *Id.*, 2:52-59, 3:19-35. Tong describes mobile devices that operate within a wireless network that include circuitry for converting RF signals to baseband signals. EX1005, [0074]; Section VII.B. Tong further teaches the conventional practice in which a mobile device (receiver) receives signals, determines channel matrix H, performs an SVD on channel matrix H to determine unitary matrix V, decomposes matrix V using a "Givens transform," and then sends data generated from the Givens transform to the transmitter. *Id.*, [0223]-[0224]. Mao suggests using a wireless communication system (*e.g.*, receiver beam-forming system) with RF units/frequency converters that transform received RF signals to "base-band signals." EX1006, 3:28-36, 7:34-35; Section VII.C.

A POSITA would have been prompted to implement Li-748's wireless station in the predictable manner suggested by Tong ("receive an RF signal and[] convert the RF signal into a baseband signal" in Element [9.a] and "decompose" unitary matrix V using a traditional "Givens rotation" in Element [9.f]) and by Mao ("form a baseband signal" in Element [9.g]) to achieve a number of known benefits. EX1003, ¶¶77-79, 94-97.

Elements [1.P], [9.P], [17.P]

To the extent the preamble is limiting, Li-748 discloses this element. EX1003, ¶73. With reference to Figures 1 and 4, Li-748 discloses "***electronic system*** 400" which "may be utilized in a ***wireless*** network as ***station*** 102 or ***station*** 104." EX1004, 9:32-46, FIGs. 1, 4. Li-748 further discloses that the method of Figure 2 is "performed by a ***wireless communications device***." *Id.*, 8:60-64.

Element [9.a]

The predictable combination of Li-748 and Tong discloses this element. EX1003, ¶¶74-79. As an initial matter, Li-748 system provides this element when antennas 410 for sending and receiving signals and "[p]hysical layer (PHY) 430 [that] is coupled to antennas 410 to interact with a wireless network." EX1005, 9:55-63, FIG. 4. Specifically, Li-748 discloses that "PHY 430 includes an ***RF receiver to receive signals and perform 'front end' processing***," "transform mechanisms and beam forming circuitry to support MIMO signal processing," "***circuits to support frequency up-conversion***, and an RF transmitter." *Id.*, 9:66-10:6. Based upon Li-748's teaching, a POSITA would have understood that Li-748's antennas and RF receiver are a plurality of RF components operable to receive an RF signal (as was conventional) and that Li-748's "front end" processing performed by the RF receiver included the typical converting of the RF signal to a baseband signal for further processing by the base station. EX1003, ¶76. Li-748 teaches this conventional element.

Even if Li-748 did not expressly state that RF components operate "to receive an RF signal and to convert the RF signal to a baseband signal," such a feature was ubiquitous in similar mobile devices, as evidence by Tong. EX1003, ¶77. For example, with reference to Figure 3, Tong's mobile device includes "a control system 32, a baseband processor 34, transmit circuitry 36, ***receive circuitry 38***, multiple antennas 40, and a network interface 42," where the "***receive circuitry 38 receives radio frequency signals bearing information from one or more base stations 14***." EX1005, [0077]. "***Downconversion and digitization circuitry***" is used to "***downconvert the filtered, received signal to*** an intermediate or ***baseband frequency signal***, which is then digitized into one or more digital streams." *Id.* A POSITA would have recognized this was the then-common practice for such mobile devices at the time. EX1003, ¶¶77-78.

The evidence here shows multiple reasons existed that would have prompted a POSITA to implement the device of Li-748 in a manner suggested by Tong to receive an RF signal and then convert the signal into baseband signals. **First**, such a predictable implementation of Li-748 would have predictably provided a mobile device that would convert the received RF signals to baseband signals to advantageously and properly prepare for a digital conversion (to a digital signal) for processing by the digital electronics of the mobile device. EX1003, ¶78. At the time, such mobile devices included electronic components that processed digital signals (not analog), and a POSITA would have recognized the benefits of the widely ubiquitous practice of converting the received RF signals to baseband signals for purposes of then converting to digital signals (for use internal to the mobile device). EX1003, ¶78. **Second**, this ordinary implementation of Li-748 would have been merely the application of a known technique (*e.g.*, receiving and converting RF signals to baseband signals, as suggested by Tong) to a known system (Li-748's device) ready for improvement to yield predictable results. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). A POSITA would have recognized that applying Tong's suggestion of receiving and converting RF signals to Li-748's device would have led to predictable results without significantly altering or hindering the functions performed by the device. EX1003, ¶79.

Element [9.b][3]

Li-748 discloses this element. EX1003, ¶¶80-81. Li-748 discloses that its wireless device (*e.g.*, station) includes "antennas 410, physical layer (PHY) 430, … ***processor*** 460, and ***memory*** 470." EX1004, 9:33-36. Li-748 states that the "processor 460 reads instructions and data from memory 470 and performs actions in response thereto," and, for example, that the "processor 460 may access instructions from memory 470 and perform method embodiments of the present invention, such as method 200 (FIG. 2)." *Id.*, 10:16-22. Based upon Li-748's teaching, a POSITA would have recognized that Li-748's above-described structures provided a baseband processing module, as was widely common in most mobile devices like Li-748. EX1003, ¶81.

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[3] BNR has conceded that this element was well known; the Court similarly acknowledge that such a "baseband processing module" was known. EX1020, 111:4-10 (conceding that "a baseband processor or processing module … essentially was well known in the art and its actual operation was well known"); 117:18-22 ("THE COURT: … This is a known processing baseband processing module. … [Y]our own expert recognized as something that would be known to someone of skill in the art what that constitutes.").

Elements [1.a], [9.c], [17.a]

Li-748 discloses this element. EX1003, ¶¶82-83. Li-748 discloses that "[t]o obtain V at the transmitter, the transmitter may send ***training symbols*** to the receiver; the receiver may evaluate H, compute the matrix V'; and the receiver may feedback parameters representing V to the transmitter." EX1004, 3:31-34. A POSITA would have recognized that the "training symbols" of Li-748 are used to determine a channel response H and beamforming matrix V, just like the preamble of the '862 patent. EX1003, ¶83 (citing to col. 13:37-47). Indeed, the '862 patent confirms that the wireless communication device "receiv[es] a preamble sequence from the transmitting wireless device and estimat[es] a channel response (H) from the preamble sequence." EX1001, 14:21-24. This "preamble" mentioned in the '862 patent also used the traditional "training symbols" (col. 13:40-44), as was customary at the time for purposes of estimating a channel response (H) and using the channel response to calculate the beamforming matrix V. EX1003, ¶83.

Elements [1.b], [9.d], [17.b]

Li-748 discloses this element. EX1003, ¶¶84-85. Li-748 discloses that "***channel state information is estimated from received signals***," where the "channel state information may include the ***channel state matrix H***." EX1004, 8:4-7; FIG. 2.

Elements [1.c], [9.e], [17.c]

Li-748 discloses this element. EX1003, ¶¶86-87. Li-748 discloses that a "**transmit beamforming matrix**" referred to as V may be found by:

> using SVD as follows:
>
> H=UDV'
>
> X=Vd
>
> where d is the n-vector of code bits for n data streams; x is the transmitted signal vector on the antennas; ***H is the channel matrix***; H's singular value decomposition is H=UDV'; U and V are unitary; D is a diagonal matrix with H's eigenvalues; V is n by n, and n is the number of spatial channels.

EX1004, 3:19-32. Based upon Li-748's teaching, a POSITA would have recognized that, in this widely known SVD equation (H=UDV'), channel matrix "H" was ordinary symbol for the channel response, matrix "V" was the ordinary symbol for the transmit beamforming matrix, and matrix "U" was the ordinary symbol for the receiver beamforming unitary matrix. EX1003, ¶87.

Elements [1.d], [9.f], [17.d]

The predictable combination of Li-748 and Tong discloses this element. EX1003, ¶¶88-91. As an initial matter, Li-748 discloses that in some embodiments, "the beamforming matrix V is represented by n^2-1 real numbers instead of $2n^2$ real numbers," and that "[b]y sending n^2-1 real numbers instead of $2n^2$ real numbers, the feedback bandwidth ***may be reduced***." EX1004, 2:63-67; *see also* 3:35-39. Notably, this teaching is similar to the '862 patent, which explains that "[w]ith a decomposed matrix form for the estimated transmitter beamforming matrix (V), the set of angles fed back to the transmitting wireless device ***are reduced***." EX1001, 13:67-14:3. A POSITA would have recognized that Li-748 and the '862 patent similarly disclosed a reduction, or decomposition, of the transmit beamforming matrix. EX1003, ¶89. Li-748 teaches this conventional element.

Even if Li-748 did not expressly state that the RF components "decompose" the estimated transmitter beamforming unitary matrix (V) to produce the transmitter beamforming information, such a feature was ubiquitous in similar mobile devices, as evidence by Tong. EX1003, ¶90. For example, Tong discloses that "[b]y ***decomposing the SVD-based unitary V matrix*** into Givens matrices, the V matrix can be represented by n^2-n independent complex parameters." EX1005, [0227]. Specifically, with reference with Figure 43 (above), Tong shows a "block diagram of a system employing an SVD based Givens transform feedback." *Id.*, [0066]; FIG. 43. Tong discloses that an SVD is performed on the channel matrix H at 328, and the "***the V matrix is decomposed by the Givens transform 330 to produce a series of matrices," each of which "can then be uniquely represented by two parameters θ and C***." *Id.* at [0223]. Here again, a POSITA would have recognized this was the then-common practice for such mobile devices at the time. EX1003, ¶¶90-91.

The evidence here shows multiple reasons existed that would have prompted a POSITA to implement the wireless device of Li-748 using the Givens rotation-based decomposition (as suggested by Tong), thereby predictably providing a wireless device that reduces feedback bandwidth by decomposing matrix V. **First**, such a predictable implementation of Li-748 would have advantageously resulted in a device that can reduce the feedback bandwidth by reducing the amount of data fed back to the transmitter. EX1003, ¶91. Indeed, Tong confirms this known benefit by explaining that such a solution would "reduce the amount of feedback required." EX1005, [0222]. A POSITA would have been implement to implement the device of Li-748 to perform a Givens rotation to decompose matrix V. EX1003, ¶91. **Second**, a POSITA would have been motivated to implement Li-748 using Tong's suggestion (e.g., for performing a Givens rotation) in order to be able to verify received data. *Id*. Specifically, this predictable implementation of Li-748 would have advantageously allowed a transmitter that receives the transmitter beamforming information from Li-748's device "to verify the integrity of the received matrix V." EX1005, [0226]; EX1003, ¶91. **Third**, this predictable implementation of Li-748's device would have been merely the application of a known technique (*e.g.*, performing a Givens rotation-based decomposition on matrix V, as suggested by Tong) to a known system (Li-748's device) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized that applying Tong's suggestion of decomposing matrix V using a conventional "Givens rotation" to Li-748's device would have led to predictable results without significantly altering or hindering the functions performed by the device. EX1003, ¶91. It would have been obvious to a POSITA to implement Li-748's device in light of Tong's suggestion for decomposing matrix V with a conventional "Givens rotation." EX1003, ¶91.

Elements [1.e], [9.g], [17.e]

The predictable combination of Li-748, Tong, and Mao discloses this element. EX1003, ¶¶92-97. As an initial matter, Li-748 provided this element in its explanation that "the receiver may evaluate H, compute the matrix V; and the receiver may feedback parameters representing V to the transmitter," and that "the number of feedback parameters used to represent V may be reduced." EX1004, 3:31-39; FIG. 2 (element 240). Based upon Li-748's teachings regarding the receiver providing feedback to the transmitter, a POSITA would have recognized that the wireless device "formed a baseband signal" as was ubiquitously performed in such wireless devices at the time. EX1003, ¶¶92-93.

Even if Li-748 did not expressly state that the mobile device would "form a baseband signal" employed by the plurality of RF components, such a feature was widely used is similar wireless devices, as evidence by each of Tong and Mao. EX1003, ¶¶94-96. First, regarding the Tong reference, it was a basic fact that "the baseband processor 34 receives digitized data … from the control system 32, which it encodes for transmission." EX1005, [0079]. Tong suggests that the "***encoded data***" should be "output to the transmit circuitry 36, where it is used by a modulator to modulate a carrier signal that is at a desired transmit frequency or frequencies." *Id.* Tong further discloses that for providing output streams of data, each of the "signals is ***up-converted*** in the digital domain to an intermediate frequency and converted to an analog signal via the corresponding digital up-conversion (DUC) and digital-to-analog (D/A) conversion circuitry 66. The ***resultant (analog) signals are then simultaneously modulated at the desired RF frequency***, amplified, and ***transmitted via the RF circuitry 68 and antennas 28***." *Id.*, [0087]. Based upon Tong's teaching, a POSITA would have plainly recognized that these "resultant signals" were conventional baseband signals generated by Tong's baseband processor. EX1003, ¶¶94-95. Tong expressly suggests this element (just as it also suggested the conversion of the RF signal into a baseband signal in Element [9.a]). For the same reasons articulated above (*supra*, Analysis of Element [9.a]), a POSITA would have been prompted to implement the device of Li-748 in a manner suggested by Tong (to form baseband signals) to achieve known benefits at the time—including the advantageous and customary conversion between digital signals and RF signals and vice versa. EX1003, ¶95.

Second, regarding the Mao reference, Mao also confirms that it was widely known in such mobile devices to use "a plurality of ***antenna elements*** that receive and ***transmit radio-frequency signals***, ***one or more radio-frequency units and frequency converters configured to … transform analog transmit base-band signals into a transmit RF signals***." EX1006, 3:28-36. Mao further discloses "***a plurality of up-converters which transform base-band signals into RF signals***." *Id.*, 6:34-35. Even if Tong does not expressly state that Tong's "resultant (analog) signals" were "baseband signals" as recited in Element [9.g], Mao plainly teaches the conventional practice of forming "base-band signals" as recited in this element.

The evidence here shows multiple reasons existed that would have prompted a POSITA to implement the station of Li-748 in a manner suggested by Mao to form a baseband signal employed by the plurality of RF components. **First**, such an implementation of Li-748 would have predictably provided a wireless device that would convert the digital signal (processed by the electronics of Li-748's device) to a baseband signal to advantageously prepare for wireless transmission to the remote device. EX1003, ¶97. As explained in Mao, it was conventional to form such baseband signals for purposes of "transform[ing] the base-band signals into RF signals" for transmission. *Id.* (citing col. 6:34-35). **Second**, this ordinary implementation of Li-748 would have been merely the application of a known technique (*e.g.*, forming a baseband signal employed by the plurality of RF components) to a known system (Li-748's device) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized that applying Mao's suggestion of forming baseband signals for transmission to Li-748's device would have led to predictable results without significantly altering or hindering the functions performed by the device. EX1003, ¶97.

Elements [2], [10]

The predictable combination of Li-748, Tong, and Mao teaches this claim. EX1003, ¶¶98-101. As an initial matter, Li-748 discloses determining an estimated "transmit beamforming matrix" by "using SVD" with the equation "H=UDV'" that produces matrix V in Cartesian coordinates. EX1004, 3:19-23. Li-748 also discloses that "the beamforming matrix V is represented by n^2-1 real numbers instead of $2n^2$ real numbers." *Id.* at 2:63-65.

Even if Li-748 did not expressly state that matrix V is produced in "Cartesian coordinates" and then converted to polar coordinates, such a feature was ubiquitous in similar devices, as evidenced by Tong. EX1003, ¶99. For example, Tong discloses "employing an SVD based Givens transform feedback" and "***the V matrix is decomposed*** by the Givens transform 330 to produce a series of matrices," which "can then be uniquely represented by ***two parameters Θ and C***." EX1005, [0066], [0223]. Tong additionally discloses that a "V matrix can be decomposed into Givens matrices containing n^2-2 ***complex parameters***." *Id.*, [0222]. A POSITA would have understood that "parameters Θ and C" were the traditional polar coordinate representations of the angle and distance, respectively, and further would have recognized that Tong's reference to "complex parameters" indicated that the Givens matrices were produced in polar coordinates, in accordance with the normal practice at the time. EX1003, ¶99. Additionally or alternatively, the evidence here confirms that a POSITA would have understood that to perform Tong's suggested Givens rotation on matrix V and "produce a series of matrices" represented by "two parameters Θ and C," one would necessarily first need to convert matrix V from Cartesian to polar coordinates. EX1003, ¶99.

As discussed with respect to claim [9.f], the evidence shows multiple reasons existed that would have prompted a POSITA to implement the wireless device of Li-748 to include the Givens rotation-based decomposition of Tong (resulting in a device that further reduces feedback bandwidth by decomposing matrix V). This predictable combination would have also included a baseband module that converts the matrix V from Cartesian to polar coordinates so that matrix V would then be decomposed using a Givens rotation, as suggested by Tong and the customary practice at the time. EX1003, ¶100.

Elements [3], [11]

The predictable combination of Li-748, Tong, and Mao teaches this claim. EX1003, ¶¶102-104. Li-748 discloses that transmit beamforming matrix V may be found by "using SVD as follows:

H=UDV’

where … ***H is the channel matrix***; H’s singular value decomposition is H=UDV’; ***U and V are unitary***; ***D is a diagonal matrix*** with H’s eigenvalues.” EX1004, 3:19-32, 8:7-11, FIG. 2; *supra*, Analysis of Elements [9.e]-[9.f].

Elements [4], [12], [18]

As discussed Section VII.D (Element [11]), the predictable combination of Li-748, Tong, and Mao provides this claim element. EX1003, ¶¶105-106; EX1004, 3:19-32; *supra*, Analysis of Elements [9.b], [9.e]-[9.f], [11].

Elements [7], [15]

The predictable combination of Li-748, Tong, and Mao provides this claim element. EX1003, ¶¶208-209; EX1004, 2:6-25, FIG. 1. For example, Li-748 describes that “[e]ach of stations 102 and 104 includes ‘n’ antennas, where n may be any number” and “stations 102 and 104 [can] have an unequal number of antennas.” EX1004, 2:6-9.

Elements [8], [16]

The predictable combination of Li-748, Tong, and Mao provides this claim element. EX1003, ¶210; EX1004, 2:6-25, FIG. 1. For example, Li-748 describes that “stations 102 and 104 may communicate using Multiple-Input-Multiple-Output (MIMO) techniques.” EX1004, 2:20-25.

VIII. GROUND 2: CLAIMS 1-4, 7-12, 15-18 ARE OBVIOUS OVER TONG AND MAO

As explained in Section VII.B, Tong describes a wireless communication device and the conventional practice in which a device (receiver) receives signals, produces a channel matrix H, performs an SVD on the channel matrix H to determine beam-forming matrix V, and decomposes matrix V by the "Givens transform" to produce reduced feedback information to send to a transmitter. EX1005, [0073], [0223]. This was highly similar to the alleged solution set forth in the example of the '862 patent. EX1001, 13:58-67 ("Givens Rotation").

As detailed above, Mao demonstrates the traditional practice for such devices (*e.g.*, receiver beam-forming system) where antennas receive RF signals and RF units/frequency converters then transform the received RF signals to base-band signals. EX1006, 3:28-36, 7:34-35; Section VII.C. A POSITA would have been prompted to implement Tong's device in the predictable manner suggested by Mao ("forming a baseband signal" in Element [9.g]) to achieve a number of known benefits. EX1003, ¶¶123-125.

Elements [1.P], [9.P], [17.P]

To the extent the preamble is limiting, Tong discloses this element. EX1003, ¶¶109. With reference to Figure 1, Tong discloses "a base station controller (BSC) 10 which controls ***wireless communications*** within multiple cells 12, which cells are served by corresponding ***base stations (BS) 14***." EX1005, [0073],

FIG. 1. The "***base stations 14 and mobile terminals 16*** may include ***multiple antennas to provide spatial diversity for communications***." *Id.*

Element [9.a]

Tong discloses this element. EX1003, ¶¶110-111. With reference to Figure 3, Tong's mobile device includes "a baseband processor 34, transmit circuitry 36, ***receive circuitry 38***, multiple antennas 40, and a network interface 42," where the "***receive circuitry 38 receives radio frequency signals bearing information from one or more base stations 14***." EX1005, [0077]. "***Downconversion and digitization circuitry***" is used to "***downconvert the filtered, received signal to*** an intermediate or ***baseband frequency signal***, which is then digitized into one or more digital streams." *Id.*

Element [9.b][4]

Tong discloses this element. EX1003, ¶112. With reference to Figure 3, Tong's mobile device includes "***a baseband processor 34***." EX1005, [0077], FIG. 3. "The baseband processor 34 processes the digitized received signal to extract the information or data bits conveyed in the received signal," including "demodulation, decoding, and error correction operations." *Id.*, [0078]. It is "generally implemented in one or more digital signal processors (DSPs) or application-specific integrated circuits (ASICs)." *Id.*

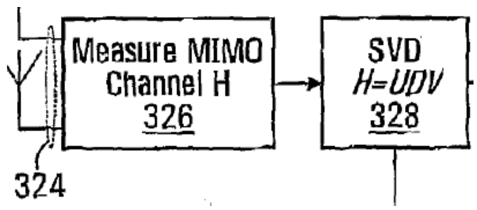
[4] *Supra*, footnote 3.

Elements [1.a], [9.c], [17.a]

Tong discloses this element. EX1003, ¶¶113-114. Tong teaches that "***pilot symbols***" are received by a receiver from a transmitter, and the "MIMO channel H is measured" by the receiver based on the pilot symbols, and beamforming matrix V is subsequently determined. EX1005, [0211], [0087]. A POSITA would have recognized that the "pilot symbols" of Tong operated like a conventional preamble to determine a channel response H and beamforming matrix V, much like the preamble of the '862 patent. EX1003, ¶114 (citing to col. 13:37-47); EX1005, [0211], [0223]; *see also* EX1001, 14:21-24. Similar to the "pilot symbols" of Tong, the preamble mentioned in the '862 patent comprises known data received from a transmitter as was traditional at the time for the purpose of estimating a channel response (H) and determining a beamforming matrix V. EX1003, ¶114 (citing to [0090], [0211]); *see* EX1001, 13:37-44.

Elements [1.b], [9.d], [17.b]

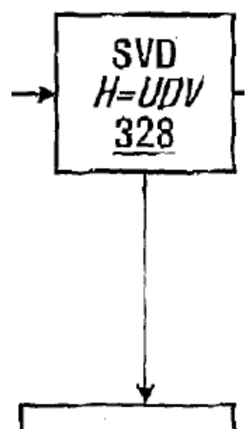
Tong discloses this element. EX1003, ¶¶115-116. Tong discloses that "***pilot symbols***" are received by a receiver from a transmitter, and the "MIMO ***channel H is measured***," or estimated, by the receiver based on the pilot symbols. EX1005, [0211], [0087], [0090] ("actual and interpolated channel responses are used to estimate an overall channel response"). Referencing Figure 43 (excerpted below), Tong discloses that "[a]t the receiver, receive antennas 324 receive signals, and the channel measurement is performed at 326," which "***produces the channel matrix***," matrix H that is then "SVD decomposed at 328":



Id., [0223], FIG. 43 (excerpted).

Elements [1.c], [9.e], [17.c]

Tong discloses this element. EX1003, ¶¶117-118. With reference to Figure 43 (excerpted below), Tong discloses that an "SVD is performed on the channel matrix H at 328" used to determine the transmit beamforming matrix V:



EX1005, [0223], FIG. 43 (excerpted).

Based upon Tong's teaching, a POSITA would have recognized that, in this commonly known SVD equation (H=UDV), channel matrix "H" was the ordinary symbol for the channel response, "V" was the ordinary symbol for the transmit beamforming matrix, and "U" was the ordinary symbol for the receiver beamforming unitary matrix. EX1003, ¶118.

Elements [1.d], [9.f], [17.d]

Tong discloses this element. EX1003, ¶¶119-120. Tong discloses that "[b]y ***decomposing the SVD-based unitary V matrix*** into Givens matrices, the V matrix can be represented by n^2-n independent complex parameters," thereby reducing the required feedback. EX1005, [0227], [0222]. With reference to Figure 43 (above), Tong shows a "block diagram of a system employing an SVD based Givens transform feedback." *Id.*, [0066], FIG. 43. Tong discloses that an SVD is performed on the channel matrix H at 328, and the "***the V matrix is decomposed by the Givens transform 330 to produce a series of matrices," each of which "can then be uniquely represented by two parameters Θ and C***." *Id.*, [0223]. Here again, a POSITA would have recognized that Tong's teaching here was highly similar to the example set forth in the '862 patent. EX1001, 13:58-67 ("Givens Rotation").

Elements [1.e], [9.g], [17.e]

The predictable combination of Tong and Mao discloses this element. EX1003, ¶¶121-125. As an initial matter, Tong discloses that "the baseband processor 34 receives digitized data … from the control system 32, which it encodes for transmission." EX1005, [0079]. Tong suggests that the "***encoded data***" should be "output to the transmit circuitry 36, where it is used by a modulator to modulate a carrier signal that is at a desired transmit frequency or frequencies." *Id.* Tong further discloses that for providing output streams of data, each of the "signals is ***up-converted*** in the digital domain to an intermediate frequency and converted to an analog signal via the corresponding digital up-conversion (DUC) and digital-to-analog (D/A) conversion circuitry 66. The ***resultant (analog) signals are then simultaneously modulated at the desired RF frequency***, amplified, and ***transmitted via the RF circuitry 68 and antennas 28***." *Id.*, [0087]. Based upon Tong's teaching, a POSITA would have plainly recognized that these "resultant (analog) signals" were conventional baseband signals generated by Tong's baseband processor. EX1003, ¶122. Tong expressly suggests this element (just as it also suggested the conversion of the RF signal into a baseband signal in Element [9.a]). EX1003, ¶122.

Even if Tong did not expressly state that the mobile device would "form a baseband signal" employed by the plurality of RF components, such a feature was widely used is similar mobile devices, as further evidence by Mao. EX1003, ¶123. Mao confirms that it was widely known for mobile devices to use "a plurality of ***antenna elements*** that receive and ***transmit radio-frequency signals***, ***one or more radio-frequency units and frequency converters configured to*** … ***transform analog transmit base-band signals into a transmit RF signals***." EX1006, 3:28-36.

Mao further discloses "***a plurality of up-converters which transform base-band signals into RF signals***." *Id.*, 6:34-35. Even if Tong does not expressly state that Tong's "resultant (analog) signals" were "baseband signals" as Element [9.g] recites, Mao plainly teaches the conventional practice of forming "base-band signals" as recited in this element. EX1003, ¶124.

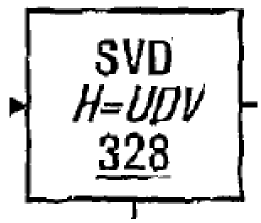
The evidence here shows multiple reasons existed that would have prompted a POSITA to implement the Tong's device in a manner suggested by Mao to form a baseband signal employed by the plurality of RF components. **First**, such a predictable implementation of Tong would have predictably provided a mobile device that would convert the digital signal (processed by the electronics of Tong's device) to a baseband signal to advantageously prepare for RF wireless transmission to the remote device. EX1003, ¶125. As explained in Mao, it was a known benefit to form such baseband signals for purposes of "transform[ing] the base-band signals into RF signals" for transmission. *Id.* (citing col. 6:34-35). **Second**, this ordinary implementation of Tong would have been merely the application of a known technique (*e.g.*, forming a baseband signal employed by the plurality of RF components) to a known system (Tong's device) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized that applying Mao's suggestion of receiving and converting RF signals to Tong's device would have led to predictable results without significantly altering or hindering the functions performed by the receiving station. EX1003, ¶125.

Elements [2], [10]

The predictable combination of Tong and Mao teaches this claim. EX1003, ¶¶126-128. Tong discloses "employing an SVD based Givens transform feedback" and "***the V matrix is decomposed*** by the Givens transform 330 to produce a series of matrices," which "can then be uniquely represented by ***two parameters Θ and C***." EX1005, [0066], [00223]. Tong additionally discloses that a "V matrix can be decomposed into Givens matrices containing n^2-2 ***complex parameters***." *Id.*, [0222]. A POSITA would have understood "parameters Θ and C" as polar coordinates that represent the angle and distance, respectively, and further recognized that Tong's reference to "complex parameters" disclosed or suggested that the Givens matrices were produced in polar coordinates, in accordance with the normal practice at the time. EX1003, ¶127. Additionally or alternatively, the evidence here confirms that a POSITA would have understood that to perform Tong's suggested Givens rotation on matrix V and "produce a series of matrices" represented by "two parameters Θ and C," one would necessarily first need to convert matrix V from Cartesian to polar coordinates. *Id*.

Elements [3], [11]

The predictable combination of Tong and Mao teaches this claim. EX1003, ¶¶129-130. With reference to Figure 43 (excerpted below), Tong discloses that an "SVD is performed on the channel matrix H at 328":



EX1005, [0223], FIG. 43 (excerpted); *supra*, Analysis of Elements [9.e]-[9.f].

Elements [4], [12], [18]

As discussed Section XIII (claim [11]), the predictable combination of Tong and Mao teaches this claim element. EX1003, ¶¶131-132; EX1005, [0223] ("produces the channel matrix which is then SVD decomposed"), FIG. 43; *supra*, Analysis of Elements [9.e]-[9.f], [11].

Elements [7], [15]

The predictable combination of Tong and Mao provides this claim element. EX1003, ¶¶211-212; EX1005, [0003], [0005]-[0006], [0073]-[0077], FIGS. 1-3. For example, Tong describes that "there are multiple transmit antennas and multiple receive antennas." EX1005, [0003], [0005].

Elements [8], [16]

The predictable combination of Tong and Mao provides this claim element. EX1003, ¶ 213; EX1005, [0002]-[0006], [0073]-[0077], FIGS. 1-3. For example, Tong describes "the invention provides a MIMO system comprising: a transmitter having multiple transmit antennas; at least one receiver, each receiver having at least one receive antenna." EX1005, [0005].

IX. GROUND 3: CLAIMS 1, 3-4, 7-9, 11-12, 15-18 ARE OBVIOUS OVER LI-054 AND MAO

A. Overview of Li-054

Li-054 is directed to a "closed loop MIMO system" that reduces "feedback bandwidth" by using "Householder transformations and vector quantization using codebooks." *Id.*, Abstract. Li-054 discloses wireless stations 102 and 104 that are part of a wireless local area network:

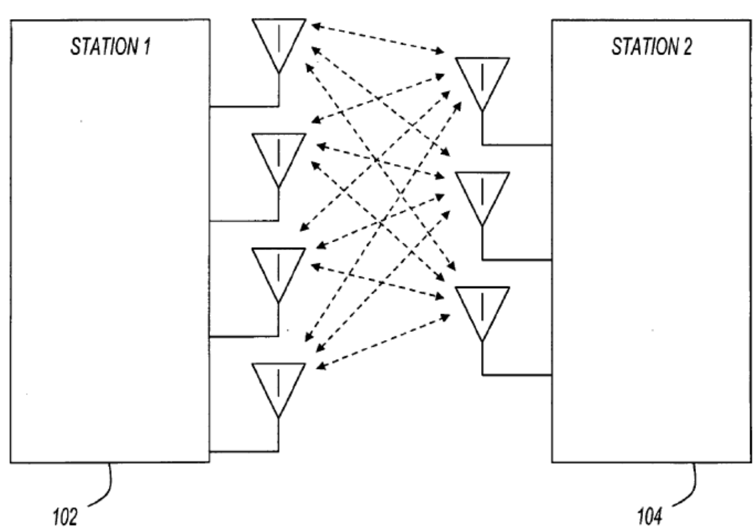


FIG. 1

Id., [0011], FIG. 1.

Figure 5 (below) shows a diagram of a system that "includes antennas 510, physical layer (PHY) 530, … processor 560, and memory 570" and can perform various operations. *Id.*, [0101]. For example, Li-054 discloses that a "receiver receives training symbols and computes the beamforming matrix, V." *Id.*, [0022]. The "beamforming matrix V is fed back from the receiver to the transmitter." *Id.*, [0019].

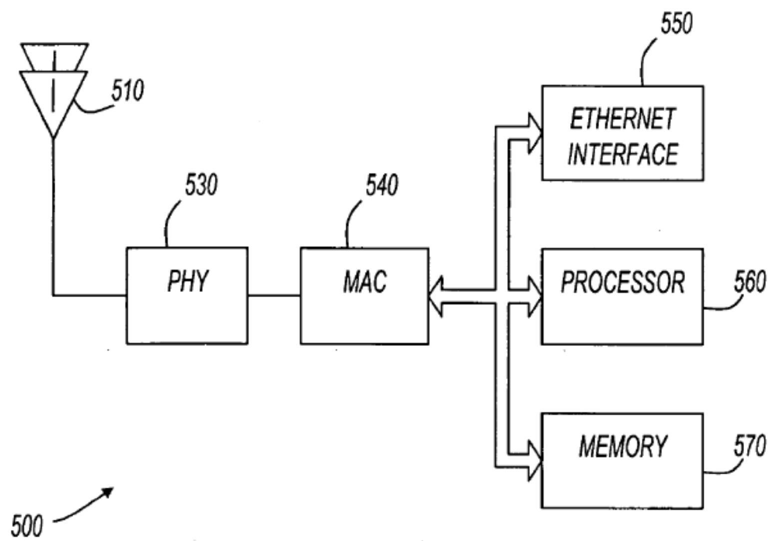


FIG. 5

Id., FIG. 5.

Li-054 describes this process in detail with reference to Figure 3. At 310, "channel state information is estimated from received signals," where the "channel state information may include the channel state matrix H." *Id.*, [0093], FIG. 3. "At 320, a beamforming matrix is determined from the channel state information," which, may "correspond[] to performing singular value decomposition (SVD)" using the equation: $H_{m\times n} = U_{m\times m}D_{m\times n}V'_{n\times n}$. *Id.*, [0093], [0018]. "At 330, a column of a beamforming matrix is quantized using a codebook," and at 340, "a householder reflection is performed on the beamforming matrix to reduce the dimensionality of the beamforming matrix." *Id.*, [0094]-[0095]. At 360, "the quantized column vectors are transmitted." *Id.*, [0096], FIG. 3.

B. Obviousness in view of Li-054 and Mao

Li-054 is directed to a conventional wireless system (*e.g.*, receiver) that estimates channel state information from received signals, determines a beamforming matrix from the estimated channel state information, and reduces the beamforming matrix before sending it to a transmitter. EX1008, [0018], [0093]-[0095]. As described above (Section VII), Mao further suggests using a wireless communication system (*e.g.*, receiver beam-forming system) that receives RF signals and RF units/frequency converters that transform the RF signals to base-band signals. EX1006, 3:28-36, 7:34-35; Section VII.C.

A POSITA would have been prompted to implement Li-054's receiver in the predictable manner suggested by Mao ("convert the RF signal to a baseband signal" in Element [9.a] and "form a baseband signal" in Element [9.g]) to achieve a number of known benefits. EX1003, ¶¶145-146, 161.

Elements [1.P], [9.P], [17.P]

To the extent the preamble is limiting, Li-054 discloses this element. EX1003, ¶140. For example, Li-054 discloses "two ***wireless stations***, station 102, and station 104," which may be part of a wireless local area network:

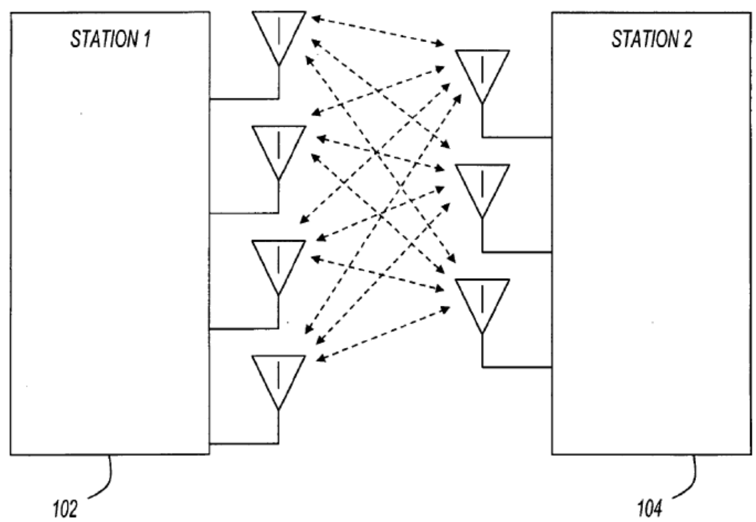


FIG. 1

EX1007, [0011], FIG. 1. Li-054 discloses that the stations include antennas and that "***may communicate*** using Multiple-Input-Multiple-Output (MIMO) techniques." *Id.*, [0013]. With reference to Figure 5, Li-054 further discloses an "electronic system 500 [that] may be utilized in a ***wireless network as station 102 or station 104***." *Id.*, [0101], FIG. 5.

Element [9.a]

The predictable combination of Li-054 and Mao discloses this element. EX1003, ¶¶141-146. As an initial matter, Li-054's electronic system 500 (*e.g.*, station) "sends and ***receives signals using antennas 510***." EX1007, [0103]. The system 500 includes a "[p]hysical layer (PHY) coupled to antennas 510 to interact with a wireless network" and "***circuitry to support the transmission and reception of radio frequency (RF) signals***." *Id.*, [0104]. "PHY 530 includes an ***RF receiver to receive signals*** and perform 'front end' processing such as … ***frequency conversion*** or the like." *Id.* A POSITA would have recognized that the conventional "antennas," "circuitry," and "RF receiver" of Li-054 provided a plurality of RF components that are operable to receive an RF signal, as recited in this claim element. EX1003, ¶143. The evidence here also confirms that POSITA would have understood Li-054's description of its RF receiver disclosed or suggested frequency conversion circuitry that converts the RF signal to a baseband signal for processing, as was nearly universal and customary in such devices at the time. *Id.*

Even if Li-054 did not expressly state that RF components operate "to convert the RF signal to a baseband signal," such a feature was ubiquitous in similar devices, as evidenced by Mao. *Id.*, ¶144. For example, Mao discloses a wireless communication system includes "a plurality of ***antenna elements*** that ***receive*** … ***radio-frequency signals, … radio-frequency units and frequency converters configured to transform received RF signals to receive analog base-band signals***." EX1006, 3:28-36.

The evidence here shows multiple reasons existed that would have prompted a POSITA to implement Li-054's station in a manner suggested by Mao to convert the received RF signals into baseband signals. **First**, such a predictable implementation of Li-054's station would have predictably provided a station that can receive RF signals and then convert them baseband signals to advantageously achieve a digital conversion (to a digital signal) for processing by the electronics of the station. EX1003, ¶145. At the time, such stations included electronic components that processed digital signals (not analog), and a POSITA would have recognized the benefits of the widely ubiquitous practice of converting the received RF signals to baseband signals for the purposes of then converting to digital signals (for use internal to the station). *Id*. **Second**, this ordinary implementation of Li-054 would have been merely the application of a known technique (*e.g.*, converting RF signals to baseband signals, as suggested by Mao) to a known system (Li-054's station) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized that applying Mao's suggestion of receiving and converting RF signals to Li-054's station would have led to predictable results without significantly altering or hindering the functions performed by the station. EX1003, ¶146.

Element [9.b][5]

Li-054 discloses this element. EX1003, ¶¶147-149. Li-054 discloses that its station includes "antennas 510, physical layer (PHY) 530, media access control (MAC) layer 540, Ethernet interface 550, ***processor*** 560, and ***memory*** 570." EX1007, [0101], FIG. 5. Li-054 states that the "processor 560 reads instructions and data from memory 570 and performs actions in response thereto," and that the "processor 560 may access instructions from memory 570 and perform method embodiments of the present invention, such as method 300 (FIG. 3) or method 400 (FIG. 4)." *Id.*, [0106]. Based upon Li-054's teaching, a POSITA would have recognized that Li-054's above-described structures provided a baseband processing module. EX1003, ¶149.

Elements [1.a], [9.c], [17.a]

Li-054 discloses this element. EX1003, ¶¶150-151. Li-054 discloses that "the receiver receives ***training symbols*** and computes the beamforming matrix, V" using the equation H=UDV'. EX1007, [0022], [0018]-[0019]. A POSITA would have further recognized that the "training symbols" of Li-054 are used to determine a channel response H and beamforming matrix V, just like the preamble of the '862 patent. EX1003, ¶151 (citing to col. 13:37-47). Indeed, the '862 patent confirms that the wireless communication device "receiv[es] a preamble sequence

[5] *Supra*, footnote 3.

from the transmitting wireless device and estimat[es] a channel response (H) from the preamble sequence." EX1001, 14:21-24. This "preamble" mentioned in the '862 patent used the same type of "training symbols" (col. 13:40-44), which was traditional at the time for purposes of estimating a channel response (H) and using the channel response to calculate the beamforming matrix V. EX1003, ¶151.

Elements [1.b], [9.d], [17.b]

Li-054 discloses this element. EX1003, ¶¶152-153. Li-054 discloses estimating "***channel state information … from received signals***" at 310, where the "channel state information may include the ***channel state matrix H***." EX1007, [0093], FIG. 3 (element 310). Li-054 further discloses that the "receiver receives training symbols and computes the beamforming matrix, V as shown" in the equation $\boldsymbol{H}_{m\times n} = \boldsymbol{U}_{m\times m} \boldsymbol{D}_{m\times n} \boldsymbol{V'}_{n\times n}$. *Id.*, [0018]-[0019].

Elements [1.c], [9.e], [17.c]

Li-054 discloses this element. EX1003, ¶¶154-155. Li-054 discloses that, after the "channel state matrix H" is estimated from the received signals, "a ***beamforming matrix is determined from the channel state information***," where the beamforming matrix is V. EX1007, [0093], FIG. 3 (element 320). Li-054 also discloses "performing singular value decomposition (SVD)" according to the equation: $\boldsymbol{H}_{m\times n} = \boldsymbol{U}_{m\times m} \boldsymbol{D}_{m\times n} \boldsymbol{V'}_{n\times n}$ where "H is the channel matrix, H's singular value decomposition is H=UDV'; U and V are unitary; [and] D is a diagonal matrix." *Id.*, [0018]-[0019], [0093].

Elements [1.d], [9.f], [17.d]

Li-054 discloses this element. EX1003, ¶¶156-157. Li-054 quantizing and performing a "householder reflection" on "the beamforming matrix to ***reduce the dimensionality of the beamforming matrix***." EX1007, [0094]-[0095]. Notably, this teaching is similar to the '862 patent, which explains that "[w]ith a decomposed matrix form for the estimated transmitter beamforming matrix (V), the set of angles fed back to the transmitting wireless device ***are reduced***." EX1001, 13:67-14:3. A POSITA would have recognized that Li-054 and the '862 patent similarly disclosed a reduction (or "decomposition") of the transmit beamforming matrix. EX1003, ¶157.

Elements [1.e], [9.g], [17.e]

The predictable combination of Li-054 and Mao discloses this element. EX1003, ¶¶158-161. As an initial matter, Li-054 discloses that after the quantizing and performing the householder reflection on the beamforming matrix V, the data is fed back to the transmitter. EX1007, [0019], [0096], FIG. 3. Li-054's device includes a "[p]hysical layer (PHY) coupled to antennas 510 to interact with a wireless network" and "circuitry to support the transmission and reception of radio frequency (RF) signals" and "circuits to support ***frequency up-conversion***, and an ***RF***

transmitter." *Id.*, [0104], FIG. 5. A POSITA would have recognized that Li-054's "frequency up-conversion" circuitry would have been used to convert a baseband signal into an RF signal for transmission as was ubiquitously performed in such devices at the time. EX1003, ¶159.

Even if Li-054 did not expressly state that the device would "form a baseband signal," such a feature was widely used in similar devices, as evidenced by Mao. EX1003, ¶160. For example, Mao confirms that it was widely known in the wireless devices to use "a plurality of ***antenna elements*** that receive and ***transmit radio-frequency signals***, ***one or more radio-frequency units and frequency converters configured to*** transform received RF signals to receive analog base-band signals and ***transform analog transmit base-band signals into a transmit RF signals***." EX1006, 3:28-36. Similar to Li-054, Mao discloses "***a plurality of up-converters which transform base-band signals into RF signals***." *Id.*, 6:29-35. For the same reasons articulated above (*supra*, Analysis of Element [9.a]), a POSITA would have been prompted to implement the device of Li-054 in a manner suggested by Mao (to form baseband signals) to achieve known benefits at the time—including the advantageous and customary conversion between digital signals and RF signals and vice versa. EX1003, ¶161.

Elements [3], [11]

The predictable combination of Li-054 and Mao teaches this claim. EX1003, ¶¶162-163. Li-054 discloses "a beamforming matrix is determined from the channel state information" by "performing singular value decomposition (SVD)" using the equation: $H_{m \times n} = U_{m \times m} D_{m \times n} V'_{n \times n}$. EX1007, [0093], [0018].

Elements [4], [12], [18]

As discussed in Section IX.B (claim [11]), the predictable combination of Li-054 and Mao teaches this claim element. EX1003, ¶¶164-165; EX1007, [0093], [0018]; *supra*, Analysis of Elements [9.e]-[9.f], [11].

Elements [7], [15]

The predictable combination of Li-054 and Mao provides this claim element. EX1003, ¶¶214-215; EX1007, [0013], [0017]-[0022], FIG. 1. For example, Li-054 describes that "station 102 includes four antennas, and station 104 includes three antennas." EX1007, [0013].

Elements [8], [16]

The predictable combination of Li-054 and Mao provides this claim element. EX1003, ¶216; EX1007, [0013]-[0016]. For example, Li-054 describes "stations 102 and 104 may communicate using Multiple-Input-Multiple-Output (MIMO) techniques." EX1007, [0013].

X. GROUND 4: CLAIMS 2, 10 ARE OBVIOUS IN VIEW OF LI-054, MAO, AND YANG

A. Overview of Yang

Yang (EX1008) was published in 1991 in the JOURNAL ON MATRIX ANALYSIS AND APPLICATIONS. EX1008, 1;EX1021, ¶¶6-8.

Yang is directed to a "method for computing two-sided rotations involved in singular value decomposition (SVD)" that "leads to significantly reduced computations." EX1008, Abstract. Yang states that a typical application of SVD arises in beam-forming, and because of the "high computational complexity of SVD," there has been "massive interest in parallel architectures for computing SVD." *Id.*, 1. Yang teaches the use of "coordinate rotation digital computer (CORDIC) processors" to avoid the "computational overhead" of previous computational methods. *Id.*, Abstract.

Yang explains that the "CORDIC algorithm" is "an iterative procedure for computing plane rotations and Cartesian-to-polar coordinates conversions." *Id.*, 4. Using this algorithm, Yang explains "the Cartesian coordinate (x_0, y_0) of a plane vector is converted to its polar representation." *Id.*, 6.

B. Obviousness in view of Li-054, Mao, and Yang

As discussed in Ground 3, the predictable combination of Li-054 and Mao renders claim 9 obvious. Regarding claim 10, even if Li-054 and Mao did not expressly disclose the common practice of converting Cartesian coordinates to polar coordinates, such a feature was often used in similar beam-forming systems, as demonstrated by Yang. EX1008, 4, 6; Section X.A. A POSITA would have been prompted to implement Li-054's receiver in the predictable manner suggested by Yang to achieve a number of known benefits. EX1003, ¶170.

Elements [2], [10]

The predictable combination of Li-054, Mao, and Yang teaches this claim. As discussed in Section IX.B (claim [9.e]), Li-054 teaches determining matrix V based on channel response H and matrix U by "performing singular value decomposition (SVD)." EX1003, ¶¶169-171; EX1007, [0018]-[0019], [0093]. Yang discloses a "CORDIC algorithm" for computing "Cartesian-to-polar coordinates conversions." EX1008, 4. Yang explains that singular value decomposition, which arises in beam-forming, has a "high computational complexity," but that the CORDIC algorithm reduces the complexity, including the step of Cartesian-to-polar coordinates conversions *Id.*, 1, 5, Abstract.

The evidence here shows multiple reasons existed that would have prompted a POSITA to modify the wireless station (*e.g.*, receiver) of Li-054 to use the CORDIC algorithm (with a Cartesian-to-polar coordinate conversion of matrix V) as suggested by Yang, thereby resulting in a station that can determine matrix V using an SVD with less computational complexity). **First**, such a predictable implementation of Li-054 would have advantageously resulted in a station that uses less processor bandwidth to determine matrix V. EX1003, ¶170. A POSITA would have been motivated to implement Li-054's station to reduce computational complexity. *Id*. **Second**, this predictable implementation of Li-054's station would have been merely the application of a known technique (*e.g.*, converting Cartesian to polar coordinates when performing an SVD, as suggested by Yang) to a known system (Li-054's wireless station) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized that applying Yang's suggestion of using the CORDIC algorithm for an SVD (converting the Cartesian coordinates of V to polar coordinates) to Li-054's station would have led to predictable results without significantly altering or hindering the functions performed by the station. EX1003, ¶170.

XI. GROUND 5: CLAIMS 1, 3-4, 7-9, 11-12, 15-18 ARE OBVIOUS IN VIEW OF POON AND MAO

A. Overview of Poon

Poon discloses a "receiving station [that] determines channel state information for N spatial channels and feeds back to the transmitting station channel state information," where the "channel state information may include a beamforming matrix to cause the transmitting station to utilize N-1 spatial channels." *Id.*, Abstract, 1:56-58, 2:5-7, FIG. 1 ("wireless stations" 102).

Poon teaches that the receiving device performs a traditional SVD operation. *Id.*, FIG. 2, 3:7-8, 3:20-58. After steps 210-230, Poon explains at 240 that "the receiving stations transmits back the channel state information describing the N-l spatial channels." *Id.*, 3:28-31. The channel state information may be "in the form of a transmit beamforming matrix," in which case "the receiver computes a transmit beamforming matrix from the current channel matrix and then sends the beamforming matrix back to the transmitter." *Id.*, 3:31-36. Poon expressly teaches that "[u]pon singular value decomposition (SVD), we have

$$H=U\Sigma V^{y}$$

where U and V are N×N unitary matrices, and Σ is a diagonal matrix with positive entries"; and "[m]atrix V is the transmit beamforming matrix." *Id.*, 3:53-58, FIG. 2.

Poon also provides details of a receiver "capable of performing channel estimation." *Id.*, FIG. 7, 6:5-17. The system "sends and receives signals using antennas 710, and the signals are processed by the various elements shown in FIG. 7." *Id.*, 6:26-28. The system includes a physical layer (730) that "is coupled to antennas 710 to interact with a wireless network" and "may include circuitry to support the transmission and reception of radio frequency (RF) signals," such as "an RF receiver to receive signals and perform 'front end' processing." *Id.*, 6:33-39. The system further includes a media access control (MAC) layer 740 and a processor

760 that "reads instructions and data from memory 770 and performs actions in response thereto." *Id.*, 6:45-54, FIG. 7.

B. Obviousness in view of Poon and Mao

Poon also discloses performing an SVD using the equation $H=U\Sigma V^y$ to determine matrix V, the transmit beamforming matrix. EX1009, 3:53-58. Similar to Poon, Mao discloses a wireless communication system (*e.g.*, receiver beam-forming system). EX1007, 3:28-30, 7:34-35; *supra*, Section VII.A. Mao's wireless communication system further explicitly discloses antennas that receive RF signals and RF units/frequency converters that transform the received RF signals to baseband signals. *Id.*, 3:28-36. A POSITA would have been prompted to implement Poon's receiver station with Mao's components that receive RF signals and perform RF and baseband signal conversions to achieve known benefits. EX1003, ¶¶186-187, 201.

Elements [1.P], [9.P], [17.P]

To the extent the preamble is limiting, Poon discloses this element. EX1003, ¶180. For example, with reference to Figure 1, Poon discloses "two ***wireless stations***" 102 and 104, which are in a wireless local area network and each include multiple antennas. EX1009, 1:56-58, 2:5-7, FIG. 1. Poon further discloses that the method shown in Figure 2 is "performed by a ***wireless communications device***." *Id.*, 3:13-14, FIG. 2.

Element [9.a]

The predictable combination of Poon and Mao discloses this element. EX1003, ¶¶181-187. As an initial matter, Poon discloses "a receiving station [that] receives a training pattern from a transmitting station" and that the receiving station has a number of "***receiving antennas***." *Id.*, 3:20-25. Poon further discloses a "wireless communications device having a combination of hardware and software components … to transmit N-1 beamforming vectors to a transmitter for use in antenna beamforming," where the device includes "***baseband data circuits*** to source data to a beamforming network." *Id.*, claims 10-11.

A POSITA would have understood that Poon's "receiving antennas" are a plurality of RF components that are operable to receive an RF signal (as was conventional) and that Poon's receiving station included circuitry, such as "baseband data circuits" that converted RF signals to baseband signals for further processing by the receiving station. EX1003, ¶¶182-184. Poon teaches this conventional element.

Even if Poon did not expressly state that the RF components operate "to receive an RF signal and to convert the RF signal to a baseband signal," such a feature was ubiquitous in similar devices, as evidenced by Mao. EX1003, ¶185. For example, Mao discloses a wireless communication system includes "a plurality of ***antenna elements*** that ***receive*** and transmit ***radio-frequency signals***, ***one or more***

radio-frequency units and frequency converters configured to transform received RF signals to receive analog base-band signals and transform analog transmit base-band signals into a transmit RF signals." *Id.*, 3:28-36. A POSITA would have recognized this was the then-common practice for such wireless devices at the time. EX1003, ¶185.

The evidence here shows multiple reasons existed that would have prompted a POSITA to implement the device of Poon in a manner suggested by Mao to receive an RF signal and then convert those signals into baseband signals. **First**, such a predictable implementation of Poon would have predictable provided a device that would receive RF signals and convert the received RF signals to baseband signals to advantageously achieve a digital conversion (to a digital signal) for processing by the electronics of the device. EX1003, ¶186. At the time, such devices included electronic components that processed digital signals (not analog), and a POSITA would have recognized the benefits of the widely ubiquitous practice of converting the received RF signals to baseband signals for purposes of then converting to digital signals (for use internal to the device). *Id*. **Second**, this ordinary implementation of Poon would have been merely the application of a known technique (*e.g.*, receiving and converting RF signals to baseband signals) to a known system (Poon's device) ready for improvement to yield predictable results. *KSR*, 550 U.S. at 417. A POSITA would have recognized that applying Mao's suggestion of receiving and converting RF signals to Poon's device would have led to predictable results without significantly altering or hindering the functions performed by the device. EX1003, ¶187.

Element [9.b][6]

Poon discloses this element. EX1003, ¶¶188-189. Poon discloses that its wireless device (*e.g.*, receiving station) includes "antennas 710, physical layer (PHY) 730, media access control (MAC) layer 740, Ethernet interface 750, ***processor*** 760, and ***memory*** 770." EX1009, 6:5-9. Poon states that the "processor 760 reads instructions and data from memory 770 and performs actions in response thereto," and, for example, that the "processor 760 may access instructions from memory 770 and perform method embodiments of the present invention, such as method 200 (FIG. 2)." *Id.*, 6:53-57. Based on Poon's teaching, a POSITA would have recognized that Poon's above-described structure provided a baseband processing module. EX1003, ¶189.

Elements [1.a], [9.c], [17.a]

Poon discloses this element. EX1003, ¶¶190-191. Poon teaches that the "receiving station receives a ***training pattern***" used to determine a channel response H and beamforming matrix V. EX1009, 3:20-60. A POSITA would have

[6] *Supra*, footnote 3.

recognized that the training pattern of Poon is used to determine a channel response and beamforming matrix V, just like the preamble of the '862 patent. EX1003, ¶191 (citing to col. 13:37-47). Indeed, the '862 patent confirms that the wireless communication device "receiv[es] a preamble sequence from the transmitting wireless device and estimat[es] a channel response (H) from the preamble sequence." EX1001, 14:21-24. This "preamble" mentioned in the '862 patent used "training symbols" (col. 13:40-44) as was traditional at the time for purpose of estimating a channel response (H) and using the channel response to calculate the beamforming matrix V. EX1003, ¶191.

Elements [1.b], [9.d], [17.b]

Poon discloses this element. EX1003, ¶¶192-193. Poon discloses that "[a]t 220, the receiving station ***estimates N spatial channels***, where N is equal to a number of receiving antennas." EX1009, 3:23-25. "In some embodiments, this may correspond to station 104 computing a current ***channel matrix*** describing the current state of the N spatial channels." *Id.*, 3:25-28; *see id.*, FIG. 2. Based on Poon's teaching, a POSITA would have recognized that Poon's estimates of the channel or channel matrix are estimated channel responses. EX1003, ¶193

Elements [1.c], [9.e], [17.c]

Poon discloses this element. EX1003, ¶¶194-195. Poon discloses that "the receiver computes a transmit beamforming matrix from the current channel matrix." EX1009, 3:31-36. Poon further discloses "singular value decomposition (SVD)" using the equation "$H=U\Sigma V^{y}$ where U and V are N×N unitary matrices, and Σ is a diagonal matrix," and "[m]atrix V is the transmit beamforming matrix." *Id.*, 3:53-58.

A POSITA would have recognized that the widely known SVD equation $H=U\Sigma V^{y}$ is used by the receiver to "compute[] a transmit beamforming matrix [V] from the current channel matrix [H]" and the receiver beamforming unitary matrix [U]. EX1003, ¶195.

Elements [1.d], [9.f], [17.d]

Poon discloses this element. EX1003, ¶¶196-197. Poon discloses that in some embodiments, "one spatial channel is always punctured, and the transmit beamforming matrix is reduced in size, thereby reducing the feedback bandwidth." EX1009, 3:36-39. Notably, this teaching is similar to the '862 patent, which explains that "[w]ith a decomposed matrix form for the estimated transmitter beamforming matrix (V), the set of angles fed back to the transmitting wireless device are reduced." EX1001, 13:67-14:3. A POSITA would have recognized that Poon and the ’862 patent similarly disclosed a reduction, or decomposition, of the transmit beamforming matrix. EX1003, ¶197. Poon teaches this conventional element.

Elements [1.e], [9.g], [17.e]

The predictable combination of Poon and Mao discloses this element. EX1003, ¶¶198-201. Poon discloses that “at 240, the receiving station[] transmits back the channel state information describing the N-1 spatial channels,” and “the channel state information is in the form of a transmit beamforming matrix.” EX1009, 3:29-33.

To the extent that Poon does not expressly use the phrase “form a baseband signal employed by the plurality of RF components,” such a feature was widely used in similar devices, as evidenced by Mao. EX1003, ¶¶200-201. For example, Mao confirms that it was widely known for a wireless communication system to include “***antenna elements*** that receive and ***transmit radio-frequency signals***, ***… radio-frequency units and frequency converters configured to*** … ***transform analog transmit base-band signals into a transmit RF signals***.” *Id.*, 3:28-36. Mao further discloses a “transmission beam-forming system” that includes “an antenna array system and a plurality of RF units which may be shared with the receiver beamforming system, [and] ***a plurality of up-converters which transform baseband signals into RF signals***.” *Id.*, 6:29-35.

Elements [3], [11]

The predictable combination of Poon and Mao teaches this claim. EX1003, ¶¶202-203. Poon discloses "[u]pon singular value decomposition (SVD), we have

$$H=U\Sigma V^{y}$$

where ***U and V are N×N unitary matrices***, and ***Σ***[7] ***is a diagonal matrix***"; and "[m]atrix V is the transmit beamforming matrix." EX1009, 3:53-58.

Elements [4], [12], [18]

As discussed in Section X.B (claim [11]), the predictable combination of Poon and Mao teaches this claim. EX1003, ¶¶204-205; *Id.*, 3:53-58.

Elements [7], [15]

The predictable combination of Poon and Mao provides this claim element. EX1003, ¶¶217-218; EX1009, 2:5-23, FIG. 1. For example, Poon describes that "[s]tation 102 includes 'N' antennas, and station 104 includes 'M' antennas, where N and M may be any number." EX1009, 2:5-8.

Elements [8], [16]

The predictable combination of Poon and Mao provides this claim element. EX1003, ¶219; EX1009, 2:5-23, FIG. 1. For example, Poon describes "stations 102 and 104 may communicate using Multiple-Input-Multiple-Output (MIMO) techniques." EX1009, 2:18-21.

[7] *Supra*, footnote 1.

XII. THE BOARD SHOULD CONSIDER THE PETITION ON THE MERITS AND NOT EXERCISE ITS DISCRETION TO DENY INSTITUTION

A. The *General Plastic* Factors Weigh Against Exercising Discretion To Deny Institution

An IPR petition (IPR2020-00108) was previously filed against the '862 patent on November 12, 2019, by a different petitioner, separately and independent of Apple. The present petition relies on the same grounds as the prior petition. After institution of the prior petition, the parties settled, and terminated the IPR.

Evaluation of *General Plastic* factors weighs against using the Board's discretion to deny this petition without consideration on the merits, especially where the present petitioner is different from the petitioner in the earlier-filed IPR. *General Plastic Industrial Co., Ltd. v. Canon Kabushiki Kaisha*, IPR2016-01357—01361, Paper No. 19 at pp. 9-10 (Sept. 6, 2017) (PTAB Precedential); *see also*, *Acronis, Inc., v. Realtime Data LLC*, IPR2018-00706, Paper 11, 15-16 (Oct. 1, 2018).

Factor 1: *whether the same petitioner previously filed a petition directed to the same claims of the same patent*

Apple has not previously filed any petition challenging the '862 patent. *Toshiba America Information Systems v. Walletex Microelectronics LTD.*, IPR2018-01538, Paper 11, 20 (March 5, 2019) (concerns of strategically staging petitions "have less persuasive value when the second petition is filed by a different petitioner."). Apple and the earlier petitioners remain "distinct parties, with ultimately distinct interests, and distinct litigation strategies," and are "often competitors in the marketplace." *Id.* at 22.

Factor 2: ***whether at the time of filing of the first petition the petitioner knew of the prior art asserted in the second petition or should have known of it***

Petitioner is advancing grounds that were instituted in an earlier proceeding that later settled and terminated. That is, Grounds 1-5 are based on primary references that were relied upon in the earlier IPR filed by LGE and present no additional burden on BNR or the Board (particularly because the prior proceeding terminated after institution but before a final written decision). Indeed, because Apple was not the prior petitioner and was not facing a lawsuit involving the '862 patent at the time of the LGE petition, Apple did not have any reason to know of the prior art at the time of its filing. BNR did not file suit against Apple until after the LGE IPR was terminated, so Apple had no reason to identify prior art applicable to the '862 patent at the time when the LGE IPR petition was filed. See *Gen. Plastic*, Paper 19, 16.

Factor 3: ***whether at the time of filing of the second petition the petitioner already received the patent owner's preliminary response to the first petition or received the Board's decision on whether to institute review in the first petition***

Apple did not delay filing this petition for the purpose of using an earlier proceeding as a roadmap. Rather, BNR filed its complaint against LGE on December 20, 2018, LGE filed its IPR petition on December 19, 2019, and the parties terminated the proceeding in July 2020. Apple was not a party to any dispute with BNR regarding the '862 patent until August 11, 2021—***more than a year*** after the LGE-BNR settlement and could not have been reasonably expected to file this petition any earlier. Any delay in Apple's filing of the instant petition is the direct result of BNR's litigation activity, not any gamesmanship by Apple. *Apple Inc. v. UUSI, LLC*, IPR2019-00358, Paper 12, 17 (August 5, 2019).

Factor 4: ***the length of time that elapsed between the time the petitioner learned of the prior art asserted in the second petition and the filing of the second petition***

Petitioner worked diligently to identify prior art and file the present petition since being sued on the '862 patent and the timing is particularly reasonable given BNR filed its complaint against Petitioner in August 2021, so Petitioner had no reason to consider the prior art asserted in this petition until at least service of the complaint and now files this petition less than two months after being served the complaint and learning of the prior art.

Factor 5: ***whether the petitioner provides adequate explanation for the time elapsed between the filings of multiple petitions directed to the same claims***

of the same patent

BNR did not file its complaint against Petitioner until over a year after the last pending IPR against the '862 patent settled, so Petitioner did not have an opportunity to file its petition until August 2021 at the earliest. The present petition is filed less than two months after BNR filed its complaint against Petitioner.

Factor 6: ***the finite resources of the Board*****; and Factor 7:** ***the requirement under 35 U.S.C. § 316(a)(11) to issue a final determination not later than 1 year after the date on which the Director notices institution of review***

The sixth and seventh factors weigh in favor of considering this petition when considering the limited resources of the Board, balanced against the usefulness of invalidating patents in view of the relevant prior art cited here. Because Petitioner filed a single petition against the '862 patent and has a meaningful due process interest to be heard in this forum on the merits in light of the termination of the earlier IPR proceedings against the '862 patent, the *General Plastic* factors weigh in favor of instituting IPR.

B. The *Fintiv* Factors Weigh Against Exercising Discretion To Deny Institution

This petition is being filed less than two months after the filing of the complaint, before Apple's answer to the complaint is due and before any procedural schedule has been entered. The *Fintiv* factors weigh against discretionary denial.[8]

Factor 1: *Institution Supports a Stay*

This petition precedes even the proposal, much less entry of any procedural schedule in the co-pending litigation, within which Apple intends to move for a stay if this petition is instituted. Factor 1 does not support discretionary denial and, at worst, is neutral.

Factor 2: *Proximity of the Trial Date*

No schedule has been entered and no trial date set. And because Apple moved so quickly to file the present petition, the expected final written decision deadline of April 2023 is likely to occur ***before*** trial.

Factor 3: *Petitioner's Diligence and Investment in the IPR Outweighs the Parties' Minimal Investment in Litigation*

Petitioner has filed at a very early stage of the litigation—a fact that "has weighed against exercising the authority to deny institution under *NHK*." *Apple, Inc. v. Seven Networks*, IPR2020-00156, Paper 10 at 11-12 (June 15, 2020).

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[8] Apart from Apple's showing that the *Fintiv* factors favor institution, the *Fintiv* framework should not be followed because it is legally invalid. The framework (1) exceeds the Director's authority, (2) is arbitrary and capricious, and (3) was adopted without notice-and-comment rulemaking.

Factor 4: ***Apple's Early Filing Removes the Risk of Duplicated Effort and Inconsistent Results***

The co-pending litigation is in its infancy. At present, there is no overlap in issues between the litigation and any IPR resulting from this petition. A lack of such overlap "has tended to weigh against exercising discretion to deny institution." *Fintiv*, IPR2020-00019, Pap. 11, 12-14. Moreover, as discussed above, the expected final written decision deadline of April 2023 is likely to occur ***before*** trial. And while BNR has filed a complaint in the ITC alleging infringement of the '862 patent, Petitioner is not a party to that proceeding.

Factor 5: ***Institution Would Promote Judicial Efficiency***

Petitioner and BNR are parties to the co-pending litigation. At worst, where the parties are the same such as in this case, Factor 5 is neutral. *Cisco Sys., Inc. v. Ramot at Tel Aviv Univ. Ltd.*, IPR2020-00122, Paper 15 at *10 (PTAB May 15, 2020) (APJ Crumbley, dissenting).

Factor 6: ***The Merits of this Petition and Prior Institution Strongly Favor Institution***

The merits of this Petition are particularly strong, especially in view of the Board's prior institution of IPR2020-00108 on the same grounds, and as such, Board resources may be saved by making use of work already performed by the Board. The strength of the merits alone is enough to outweigh any inefficiencies born of parallel litigation (and as explained above, institution of this petition would actually promote efficiency). *See Fintiv* at 14-15.

C. The *Becton, Dickinson* Factors Weigh Against Exercising Discretion To Deny Institution

Exercise of discretion under §325(d) would be inappropriate here because none of the art relied upon was cited or relied upon during prosecution of the '862 patent. The plain errors of the examiner in failing to cite or apply those references are highlighted by the element-by-element analysis set forth herein and by the Wells declaration (EX1003). *Supra*, Grounds 1-4. Indeed, nothing in the prosecution record applies or analyzes any of the references in a manner cumulative to the analysis in the present petition. As a result, the *Becton, Dickenson* factors weigh against exercising §325(d) discretion. *See* IPR2017-01586, Paper 8, 17-28 (Dec. 15, 2017); Pet., 7.

XIII. CONCLUSION

Petitioner requests IPR of the Challenged Claims based upon the Grounds 1-5.

Respectfully submitted,

Dated: October 4, 2021

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CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter partes* Review totals 13,974 words, which is less than the 14,000 allowed under 37 CFR § 42.24(a)(i).

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on October 4, 2021, a complete and entire copy of this Petition for *Inter Partes* Review and all supporting exhibits were provided via Federal Express, to the Patent Owner by serving the correspondence address of record as follows:

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