

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.;
SAMSUNG ELECTRONICS AMERICA, INC.,
Petitioner

v.

EMPIRE TECHNOLOGY DEVELOPMENT LLC,
Patent Owner.

Case No. IPR2024-00896
U.S. Patent No. 8,798,120

**DECLARATION OF MATTHEW C. VALENTI
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 8,798,120**

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I. INTRODUCTION

1. I have been retained by Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (collectively, “Samsung” or “Petitioner”), as an independent expert in this proceeding before the Patent Trial and Appeal Board (“PTAB” or “Board”). I understand that Samsung is requesting that the Board institute an *inter partes* review (“IPR”) proceeding of Claims 25-29 of U.S. Patent No. 8,798,120 (“the ’120 Patent”) (Ex-1001), currently assigned to Empire Technology Development LLC (“PO”).

2. I am not and have never been an employee of Samsung. I am being compensated at my usual and customary rate of \$550 per hour. No part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I have been asked to provide my independent analysis of the ’120 Patent in light of the prior art publications cited below. I have also been asked to consider the state of the art and prior art available as of October 1, 2007. Based on the prior art discussed in this declaration, it is my opinion that Claims 25-29 of the ’120 Patent are unpatentable for the reasons provided below.

A. Qualifications

4. I received a Bachelor of Science degree in Electrical Engineering from Virginia Polytechnic Institute & State University (Virginia Tech) in May 1992. I

received a Master of Science degree in Electrical Engineering from Johns Hopkins University in May 1995 and a Ph.D. in Electrical Engineering from Virginia Tech in 1999.

5. From 1992 to 1995 I served as an Electronics Engineer at the U.S. Naval Research Laboratory in Washington DC. During this time, I worked on signal processing systems, including systems that used adaptive antenna arrays.

6. From 1995 to 1999, I was a Graduate Research Assistant and Instructor in the Bradley Department of Electrical and Computer Engineering at Virginia Tech. For my Ph.D. research while working as a research assistant, I conducted in-depth investigations into signal processing and error-control coding techniques specifically tailored for mobile radio systems including cellular networks.

7. From 1999 to present, I have been a faculty member at West Virginia University in Morgantown, West Virginia. I was initially appointed as an Assistant Professor, was promoted to Associate Professor with tenure in 2005, and then was promoted to Professor in 2010. At WVU, I regularly teach the senior undergraduate course on Wireless Networking (CPE 462), which covers key concepts behind modern cellular networks, including orthogonal frequency division multiple access (OFDMA), multiple-input multiple-output (MIMO) antenna systems, and link adaptation. I also teach graduate courses on Coding Theory (EE 567) and Communication Theory (EE 561). In addition to my teaching, I run an active funded

research program focused on wireless communications and signal processing. I have advised over 50 graduate students who worked in my lab, including 10 Ph.D. students, to degree completion.

8. I have authored numerous technical papers on various aspects of mobile and wireless communication systems that have been published in well-respected, peer-reviewed journals, such as the *IEEE Transactions on Communications*, *IEEE Transactions on Wireless Communications*, and the *International Journal on Wireless Information Networks*.

9. I have extensive experience in developing software for the simulation and implementation of various aspects of wireless communication systems, including error-control coding and adaptive modulation. My software is freely available to the public in a package called the *Coded Modulation Library (CML)*¹. The software implements certain portions of several standardized systems including WiMAX, UMTS, HSDPA, and LTE.

10. I have experience designing transmission and reception schemes for MIMO communication systems. For instance, in the paper “Efficiently decoded full-rate space-time block codes,” published in the February 2010 issue of *IEEE Transactions on Communications*, I devised a class of efficient space-time codes suitable for transmission from 3, 4, or 5 antennas.

¹ <https://github.com/wvu-wcrl/CML>.

11. I am an active member of the Institute for Electrical and Electronic Engineers (IEEE), the world's largest technical professional organization with the aims of fostering technological innovation and excellence. As an IEEE member, I have been involved in running some of the most impactful journals and conferences in the field of wireless communications. For instance, I have served in many roles for *IEEE Transactions on Wireless Communications*, including chairing the Executive Editorial Committee and chairing the Steering Committee. Moreover, I have served in various program committee roles including serving as Technical Program Chair, which is the top technical leadership position, for the *IEEE International Conference on Communications* (ICC), which is a flagship conference of the IEEE Communications Society that attracts thousands of papers and participants annually.

12. In 2018, my research achievements were honored with elevation to IEEE Fellow status. As the most prestigious level of membership within the IEEE, the Fellow grade recognizes individuals through a stringent selection process. No more than 0.1% of IEEE members are elevated to Fellow each year, underscoring the distinction and selectivity of this recognition.

13. Since 2011, I have been registered as a Professional Engineer (P.E.) in the state of West Virginia. This licensure affirmed my engineering proficiency through the successful completion of rigorous examinations and the attaining of

sufficient experience. To retain this licensure, I remain committed to upholding these proficiencies by engaging in continuing education and contributing to the advancement of engineering knowledge.

14. Taken as a whole, my academic and practical experience have given me a substantial basis upon which to evaluate the technology that is in question in the claims of the '120 Patent. Based on my experience and education, and the acceptance of my publications and professional recognition by peers in my field, I believe that I am qualified to opine as to the knowledge and level of skill of one of ordinary skill in the art at the time of the alleged invention of the '120 Patent (which I further describe below) and what such a person would have understood at that time, and the state of the art during that time.

15. A complete copy of my curriculum vitae, which includes a list of my publications and contains further details on my education, experience, publications, patents, and other qualifications to render an expert opinion, is attached as Ex-1003.

B. Materials Considered

16. In forming my opinions, I reviewed the following documents, in addition to others I have cited in my declaration. I also relied on my own knowledge of and experience in the field of wireless data communication systems at the physical and media access control (MAC) layer.

Ex. No.	Description
Ex-1001	U.S. Patent No. 8,798,120 (“the ’120 Patent”)
Ex-1004	Prosecution History of the ’120 Patent (Application No. 12/727,049)
Ex-1005	U.S. Patent Publication No. 2006/0067263 (“Li”)
Ex-1006	Mohammad Z. Siam et al., <i>Adaptive Multi-antenna Power Control in Wireless Networks</i> , International Conference on Wireless Communications and Mobile Computing 875-880 (2006) (“Siam”)
Ex-1007	Shuguang Cui et al., <i>Modulation Optimization Under Energy Constraints</i> , 4 Institute of Electrical and Electronic Engineers International Conference on Communications 2805-2811 (2003) (“Cui-2003”)
Ex-1008	Esa Tirola and Juha Ylitalo, <i>Performance of a UMTS Uplink MIMO Scheme</i> , 1 Institute of Electrical and Electronic Engineers 58th Vehicular Technology Conference 657-661 (2003) (“Tirola”)
Ex-1009	U.S. Patent Publication No. 2007/0171808 (“Wu”)
Ex-1020	Claim Mapping Table
Ex-1021	<i>Empire Technology Development LLC v. Samsung Electronics Co., Ltd., et al.</i> , Case No. 2-23-cv-00427, Infringement Contentions (E.D. Tex. Jan. 4, 2024).
Ex-1022	Declaration of Scott Delman dated Mar. 8, 2024 (Association for Computing Machinery)
Ex-1023	Declaration of Gordon Macpherson dated Apr. 27, 2024 (Institute of Electrical and Electronics Engineers, Incorporated)
Ex-1024	Screenshot of ACM website (Siam)
Ex-1025	Shuguang Cui et al., <i>Energy-Constrained Modulation Optimization</i> . 4 Institute of Electrical and Electronic Engineers Transactions of Wireless Communications 2349-2360 (Sept. 2005) (“Cui-2005”)
Ex-1026	Shuguang Cui et al., <i>Energy-Efficiency of MIMO and Cooperative</i>

Ex. No.	Description
	<i>MIMO Techniques in Sensor Networks</i> , 22 Institute of Electrical and Electronic Engineers Selected Areas in Communications 1089-1098 (Aug. 2004) (“Cui-2004”)
Ex-1028	U.S. Patent Publication No. 2008/0095263 (“Xu”)
Ex-1029	Adam J. Tenenbaum et al., <i>Improved Sum-Rate Optimization in the Multiuser MIMO Downlink</i> , IEEE 984 (2008) (“Tenenbaum”)
Ex-1030	Runhua Chen et al., <i>Uplink Power Control in Multi-Cell Spatial Multiplexing Wireless Systems</i> , 6 IEEE Transactions of Wireless Communications 2700 (July 2007) (“Chen”)
Ex-1031	U.S. Patent Publication No. 2005/0250452 (“Walton”)
Ex-1032	Screenshot of CD contents from Cui-2003 presentation
Ex-1033	Bruno Bougard et al., <i>SmartMIMO: An Energy-Aware Adaptive MIMO-OFDM Radio Link Control for Next-Generation Wireless Local Area Networks</i> , EURASIP Journal on Wireless Communications and Networking (2007) (“Bougard”)
Ex-1034	Andreas F. Molisch et al., <i>MIMO Systems with Antenna Selection</i> , IEEE Microwave Magazine 46 (2004) (“Molisch”)
Ex-1035	Chan-Byoung Chae et al., <i>Adaptive Spatial Modulation for MIMO-OFDM</i> , IEEE Communications Society 87 (2004) (“Chae”)
Ex-1036	Kyeongjun Ko et al., <i>Low Complexity Multiuser MIMO Scheduling with Chordal Distance</i> , IEEE 80 (2008) (“Ko”)
Ex-1037	Alkan Soysal et al., <i>Optimizing the Rate of a Correlated MIMO Link Jointly over Channel Estimation and Data Transmission Parameters</i> , IEEE 74 (2008) (“Soysal”)
Ex-1038	U.S. Patent Publication No. 2005/0289367 (“Clark”)
Ex-1039	U.S. Patent Publication No. 2008/0186918 (“Tinnakornsrisuphap”)
Ex-1040	Shuguang Cui et al., <i>Cross-Layer Energy and Delay Optimization in Small-Scale Sensor Networks</i> , 6 IEEE Transactions on Wireless

Ex. No.	Description
	Communications 3688 (2007) (“Cui-2007”)
Ex-1041	U.S. Patent No. 8,315,346 (“Kim”)
Ex-1042	Karama Hamdi et al., <i>Low-Complexity Antenna Selection and User Scheduling in Cognitive MIMO Broadcast Systems</i> , IEEE 4038 (2008) (“Hamdi”)
Ex-1043	Screenshot of CD contents from Tirola presentation
Ex-1044	Chulhan Lee et al., <i>Adaptive Mode Switching in the MIMO Broadcast Channel</i> , IEEE 711 (2008) (“Lee”)
Ex-1045	Theodore S. Rappaport, <i>Wireless Communications, Principles and Practice</i> , Ch. 1, 1-24 (2nd ed., 2001)

II. LEGAL STANDARDS

17. In forming my opinions and considering the subject matter of the ’120 Patent and its claims in light of the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is summarized below.

18. I understand that earlier publications and patents may act to render a patent unpatentable for one of two reasons: (1) anticipation, and (2) obviousness.

A. Anticipation

19. It is my understanding that the claims of a patent are anticipated by a prior art reference if each and every element of the claim is found either explicitly or inherently in the reference. I understand that inherency requires a showing that the missing descriptive matter in the claim is necessarily present in the allegedly

anticipating reference, and that it would have been so recognized by a person of ordinary skill in the art (“POSITA”).

20. I understand that when a challenged claim covers several structures, either generically or as alternatives, the claim is deemed anticipated if any of the structures within the scope of the claim is found in the prior art reference.

21. Although anticipation typically involves the analysis of a single prior art reference, I understand that additional references may be used to show that the prior art reference has enabling disclosure (i.e., allows a POSITA to make the invention without undue experimentation), to explain the meaning of a term used in the prior art reference, and/or to show that a characteristic is inherent in the prior art reference.

B. Obviousness

22. I understand that a claim is invalid as obvious if it would have been obvious to a person of ordinary skill in the art at the time the alleged invention was made. This means that even if all of the elements of the claim cannot be found in a single prior art reference that would anticipate the claim, a person of ordinary skill in the art who was aware of the prior art would have been able to come up with the claimed invention. This may be the case, for example, where the missing element represents only an insubstantial different over the prior art or a reconfiguration of a

known system. I understand that in an obviousness determination, the person of ordinary skill in the art is presumed to have knowledge of all material prior art.

23. I understand that an obviousness analysis requires an understanding of the scope and content of the prior art, any differences between the alleged invention and the prior art, and the level of ordinary skill in evaluating the pertinent art.

24. I understand that when a product is available, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation, obviousness likely bars its patentability. For the same reason, if a technique has been used to improve one device and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

25. I understand that whether a prior art reference renders a patent claim unpatentable as obvious is determine from the perspective of a person of ordinary skill in the art at the time of the alleged invention. I have been told that there is not requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, but a suggestion to combine known elements to achieve the claimed invention may come from the prior art, as filtered through the knowledge of one skilled in the art. In addition, I have been told that the

inferences and creative steps a person of ordinary skill in the art would employ are relevant to the determination of obviousness.

26. I understand that one may consider, e.g., whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; (3) the claimed innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results; or (7) known work in one field of endeavor may have prompted variations of it for use in either the same field or a different one based on design incentives or other market forces that would have been predictable to a person of ordinary skill in the art.

27. I further understand that certain factors may support or rebut the obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the patented invention, skepticism of

those having ordinary skill in the art at the time of the invention, unexpected results of the invention, any long-felt but unsolved need in the art that was satisfied by the alleged invention, the failure of others to make the alleged invention, praise of the alleged invention by those having ordinary skill in the art, and copying of the alleged invention by others in the field. I understand that there must be a nexus—that is, a connection—between any such secondary considerations and the alleged invention. I also understand that contemporaneous and independent invention by others is a secondary consideration tending to show obviousness.

28. I am not aware of any allegations by the named inventors of the '120 Patent or any assignee of the '120 Patent that any secondary considerations tend to rebut the obviousness of the '120 Patent.

29. Additionally, I understand that in considering obviousness, it is important not to use the benefit of hindsight derived from the patent under consideration.

C. Level of Ordinary Skill in the Art

30. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to that patent, as well as the level of ordinary skill in that art at the time of the claimed invention. The “art” is the field of technology to which the patent is related.

31. I am informed and understand that the POSITA is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor's skill is not determinative of the level of ordinary skill. I further understand that factors that may be considered in determining level of skill include: (i) the types of problems encountered in the art; (ii) prior art solutions to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

32. I understand that a POSITA is one who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

33. A person of ordinary skill in the art ("POSITA") at the relevant time, which I have been told to consider as October 1, 2007, would have had a bachelor's degree in electrical engineering, computer science, computer engineering, or a related field, and two-to-three years of experience in the research, design, development, or testing of wireless data communication systems at the physical and media access control (MAC) layer, with additional education substituting for experience and vice versa.

34. Based on my education and experience, I would have, at least, met the criteria for a POSITA on October 1, 2007, and I still exceed it today.

D. Claim Construction

35. I understand that the United States Patent and Trademark Office interprets claim terms in an *inter partes* review proceeding under the same claim construction standard that is used in a United States federal court. I understand that under this standard, the meaning of claim terms is considered from the viewpoint of a POSITA at the time of the alleged invention.

36. I have been informed that claim terms are generally given their ordinary and customary meaning as understood by one of ordinary skill in the art in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claims terms are generally not limited by the embodiments described in the specification.

37. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I have been informed that this other evidence is often less significant and less reliable than the claims, specification, and prosecution history.

III. SUMMARY OF GROUNDS

38. I understand that Petitioner challenges the validity of Claims 25-29 of

the '120 Patent. It is my opinion that the following grounds demonstrate that Claims 25-29 of the '120 Patent are invalid.

Ground	Summary
1	Claims 25, 27, and 28 are obvious over Li (Ex-1005) in view of Siam (Ex-1006)
2	Claims 25, 27, and 28 are obvious over Li in view of Siam in further view of Cui-2003 (Ex-1007)
3	Claim 26 is obvious over Li in view of Siam in further view of Wu (Ex-1009)
4	Claim 26 is obvious over Li in view of Siam in further view of Cui-2003 in further view of Wu
5	Claim 29 is obvious over Li in view of Siam in further view of Tirola (Ex-1008)

IV. THE '120 PATENT

A. Overview of the '120 Patent

39. The '120 Patent, titled “Methods and Communication Systems Having Adaptive Mode Selection,” describes a system that selects a multiple-input-multiple-output (MIMO) or single-input-multiple-output (SIMO) transmission mode for communicating data between a mobile station and a base station in a communications system based on certain parameters. Ex-1001, Cover, 2:12-24, 2:48-55, 7:44-46. The MIMO mode communicates data using multiple transmit antennas and multiple receive antennas, and the SIMO mode communicates data using a single transmit antenna and multiple receive antennas. Ex-1001, 1:1-18.

Specifically, a controller in the mobile station receives a control signal that informs the controller whether to select a MIMO mode or a SIMO mode based on, for example, transmission circuitry power consumption of the mobile station, “idle power consumption of the mobile station,” and/or the “number of users of the communications system.” *Id.*, 7:29-36, Cls. 25, 29.

40. The alleged improvement is a system that selects a transmission mode from either a MIMO or SIMO mode based “on which mode provides a lower energy per bit for transmission in the communications system.” *Id.*, 4:47-50. But the claims are directed to predictable combinations of well-known prior-art elements in wireless communication technologies as reflected, for example, in challenged independent Claim 25, which recites:

25. A mobile station for use in a communications system comprising:

- [a] a first antenna and a second antenna;
- [b] first circuitry coupled to the first antenna and configured to process signals for transmission by the first antenna; second circuitry coupled to the second antenna and configured to process signals for transmission by the second antenna; and
- [c] a controller coupled to the first and second circuitry, wherein the controller is configured to receive a control signal and,
- [d] in accordance with the control signal, to select between a multiple-input multiple-output (MIMO) mode wherein both the first and second antennas transmit data over a communications channel and a single-input multiple-output (SIMO) mode wherein only one of the first and second antennas transmit data over a communications channel,

- [e] wherein the control signal is based, at least in part, on a power consumption of the first and second circuitry,
- [f] wherein the control signal is based, at least in part, on an idle power consumption of the mobile station.

Ex-1001, 19:1-20. Challenged dependent Claims 26-28 depend from Claim 25 and further limit the control signal of Claim 25. *Id.*, 19:21-20:2. Challenged independent Claim 29 is identical, except for the last limitation, replacing “idle power consumption of the mobile station” with “a number of users of the communications system.” *Id.*, 20:3-24.

41. As claimed, a controller in the mobile station selects either a MIMO (multiple transmitting antennas) or SIMO (single transmitting antenna) transmission mode based on a control signal that is based on parameters related to power consumption and the number of users. Annotated Figure 4, below, and the accompanying description, depicts the components of the claimed system²:

² Throughout this Declaration, I have annotated figures using color. All annotations and emphases have been added in this Declaration, unless otherwise noted.

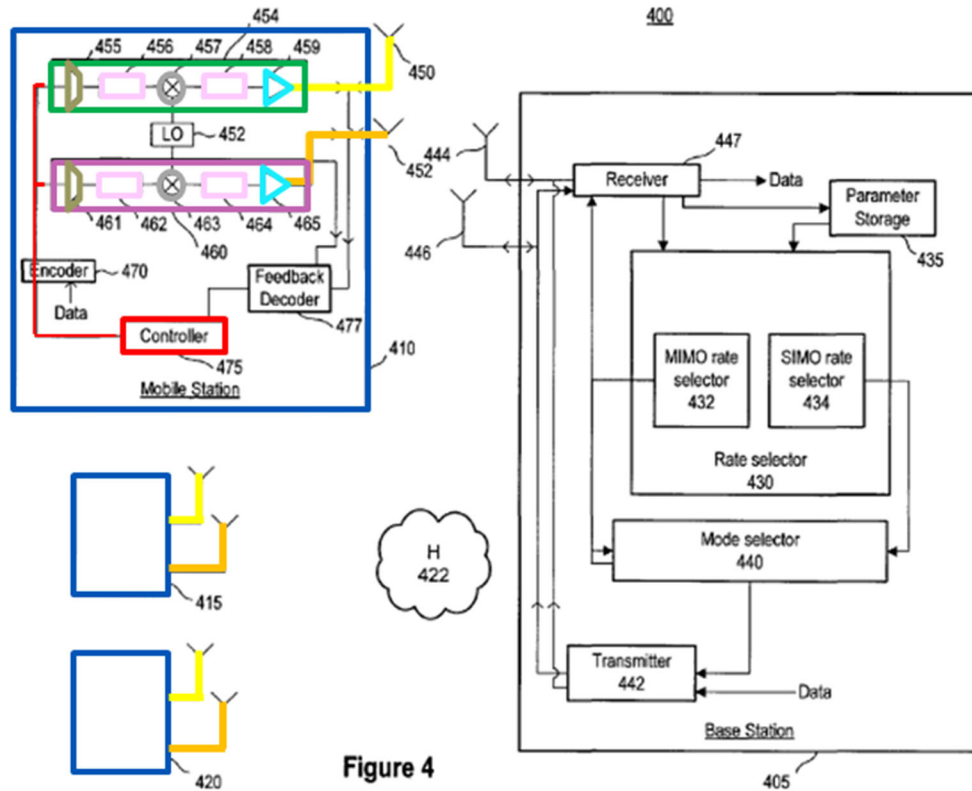


Figure 4

42. Mobile station 410 (blue) includes two antennas 450 and 452. Ex-1001, 7:17-18. First antenna 450 (yellow) is coupled to first circuitry 454 (green), which processes signals for transmission from antenna 450 and includes additional processing components indicated in various colors such as digital-to-analog converter 455 (brown), filters 456 and 458 (pink), mixer 457 (grey), and power amplifier 459 (teal). *Id.*, 7:18-22. Second antenna 452 (orange) is coupled to second circuitry 460 (purple), which processes signals from antenna 452 and includes the same additional processing components indicated with the same colors as the first circuitry such as digital-to-analog converter 461 (brown), filters 462 and 464 (pink), mixer 463 (grey), and power amplifier 465 (teal). *Id.*, 7:23-27. Controller 475 (red),

which is coupled to the first and second circuitry via encoder 470, provides “a signal to the encoder 470 to operate in a MIMO mode or a SIMO mode.” *Id.*, 7:29-33. Feedback decoder 477, which is coupled to antennas 450 and 452 and controller 475, decodes “received data and provide[s] a signal to the controller 475 corresponding to [the] selected mode.” *Id.*, 7:33-36; *see also id.*, 11:36-38 (Controller 475 receives “a signal indicative of the selected mode, selected rate, selected antenna, or combinations thereof.”). The system in Figure 4 includes a rate selector (430), which ordinarily lies in the base station but may also lie in the mobile station (Ex-1001, 8:9-19). The rate selector includes a MIMO rate selector (432) and a SIMO rate selector (434). The rate selector is coupled to a mode selector (440), which provides a signal corresponding to the selected mode (10:1-3). The selection between MIMO mode or SIMO mode considers certain parameters including “idle power consumption of one or more mobile stations, transmission circuitry power consumption of one or more mobile stations,” and “number of users of the communications system.” *Id.*, 8:34-41.

43. I note that although the '120 Patent specification generally describes embodiments in which the control signal originates at the base station (*see, e.g.*, Ex-1001, 7:44-12:27), the challenged independent claims are not so limited, broadly reciting a mobile station comprising “a controller coupled to first and second circuitry, wherein the controller is configured to receive a control signal and, in

accordance with the control signal, to select between a” MIMO and a SIMO mode. Ex-1001, Cls. 25, 29; *see also id.*, 8:9-12 (“Although shown in the base station 405, the rate selector 430 may in some embodiments be provided at one or more of the mobile stations 410, 415, and 420.”), 9:56-59 (“Although the mode selector 440 is shown in FIG. 4 in the base station 405, in other examples the mode selector 440 may be implemented in one or more mobile stations, such as the mobile station 410, 415, or 420.”).

B. Prosecution History of the ’120 Patent

44. I understand that the ’120 Patent was filed March 18, 2010 and claims priority to provisional application 61/161,166, filed March 18, 2009.

45. I have reviewed the prosecution history of the application that led to the ’120 Patent. During prosecution, challenged independent Claim 25 was first rejected over Xu (U.S. Patent No. 8,081,698) in view of Cui (Energy-Efficiency of MIMO and Cooperative MIMO Techniques in Sensor Networks, 22 IEEE Selected Areas in Communications 1089-1098 (Aug. 2004) (“Cui-2004”) (Ex-1026)) on October 15, 2012 (Ex-1004, 85-101) and again over Xu in view of Cui-2004 and Bougard (US Patent 8,140,023) on April 10, 2013 (Ex-1004, 136-154). Applicant amended challenged independent Claim 25 twice to overcome these prior art rejections—first to add the limitation reciting “wherein the control signal is based, at least in part, on a power consumption of the first and second circuitry” from a dependent claim in a

January 14, 2013 response (Ex-1004, 120-131); and second to add the limitation reciting “wherein the control signal is based, at least in part, on an idle power consumption of the mobile station” from a dependent claim in a June 28, 2013 response (Ex-1004, 165-175). Challenged independent Claim 29, originally a dependent claim reciting “wherein the control signal is based, at least in part, on a number of users of the communications system,” was changed by applicant to independent form and amended to include most of the other limitations of independent Claim 25 to overcome the pending prior art rejections in the June 28, 2013 response Ex-1004, 136-154, 165-175. The Notice of Allowance recited the “idle power consumption” and “number of users” wherein clauses as the reasons for allowance. Ex-1004, 184-190. The ’120 Patent issued on August 5, 2014. Ex-1001, Cover.

46. The prior art I apply to Claims 25-29 in my Declaration was not in the record before the USPTO during prosecution of the ’120 Patent.³ And as I discuss below, this art discloses the ’120 Patent’s Claims 25-29, including the features the

³ The Cui-2003 reference used in Ground 2 below is different from Cui-2004 that was discussed by the examiner during prosecution. And, while the office actions and notice of allowance are silent on Cui-2004’s teachings regarding the idle power consumption limitation, which was added from the dependent claim to the independent claim to overcome the prior art rejections, I note that the Cui-2003 reference below contains additional teachings on idle power consumption that are not included in the Cui-2004 reference. These teachings render at least Claim 25 obvious for the reasons discussed below.

applicant argued were new during prosecution.

V. TECHNOLOGY BACKGROUND

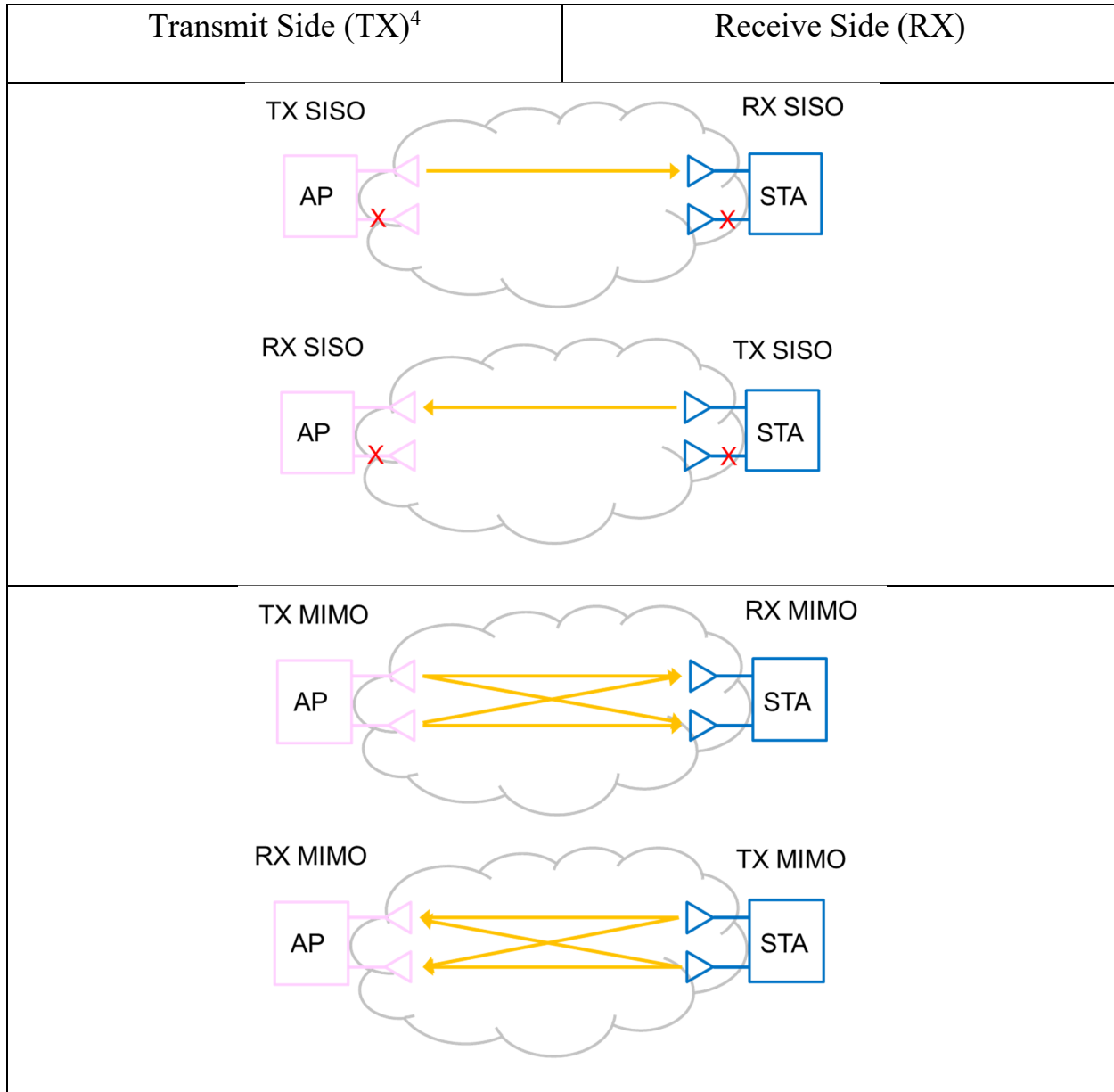
47. Wireless communication networks comprise one or more base stations, also known as access points, which provide wireless connectivity to various mobile stations. These base stations are connected to a core network, such as the Internet, and facilitate communication within designated areas called cells. Mobile stations, including devices like smartphones, tablets, and flip phones, rely on these base stations for access due to their lack of wired connectivity. Wireless networks support bi-directional communications, and thus base stations and mobile stations act as both transmitters and receivers. The link from the base station down to the mobile station is called the *downlink* while the link from the mobile station up to the base station is called the *uplink*. See, e.g., Ex-1028 (Xu) at ¶6; Ex-1029 (Tenenbaum) at 984 (discussing downlink communications from a base station to a mobile station); Ex-1030 (Chen) at 2700 (discussing uplink communications from a mobile station to a base station); Ex-1045 (Rappaport), 9-11, Table 1.4 (defining “base station” and “mobile station”).

48. When a base station and mobile station communicate, they can each use one or multiple antennas, leading to configurations known as SISO, MIMO, SIMO, and MISO. In these abbreviations, “S” stands for *single*, and “M” stands for *multiple*, referring to the number of antennas and their corresponding transmitters or receivers.

“I” denotes *input*, and “O” denotes *output*, indicating the respective ends of the wireless link. The wireless communication channel can be viewed as having one or more inputs and outputs, with the transmitter side being the input and the receiver side being the output. Thus, “SISO” (i.e., single input, single output) means a single antenna at both the transmit and receive sides, “MIMO” (i.e., multiple input, multiple output) means multiple antennas at both ends, “SIMO” (i.e., single input, multiple output) means a single antenna at the transmit side and multiple at the receive side, and finally “MISO” (i.e., multiple input, single output) means multiple antennas at the transmit side and a single antenna at the receive side. *See, e.g.*, Ex-1031 (Walton) at ¶¶38-43; Ex-1028 (Xu) at ¶6.

49. In modern wireless networks, all base stations and all mobile stations are typically equipped with multiple antennas, but the network can select an operating mode that uses any or all of these antennas and switch between operating modes, if desired, based on certain parameters. *See, e.g.*, Ex-1033 (Bougard) at 2, 13-14 (explaining that a SISO mode is better than a MIMO mode at low path loss, i.e., short distances, when circuit power is considered). Consequently, a station with multiple antennas may opt to use, for example, a single antenna mode, or fewer than all antennas, if that proves to be the most beneficial configuration. If both the base station and the mobile station activate a single antenna, the operating mode is SISO in both directions. Conversely, if both activate multiple antennas, the mode is MIMO

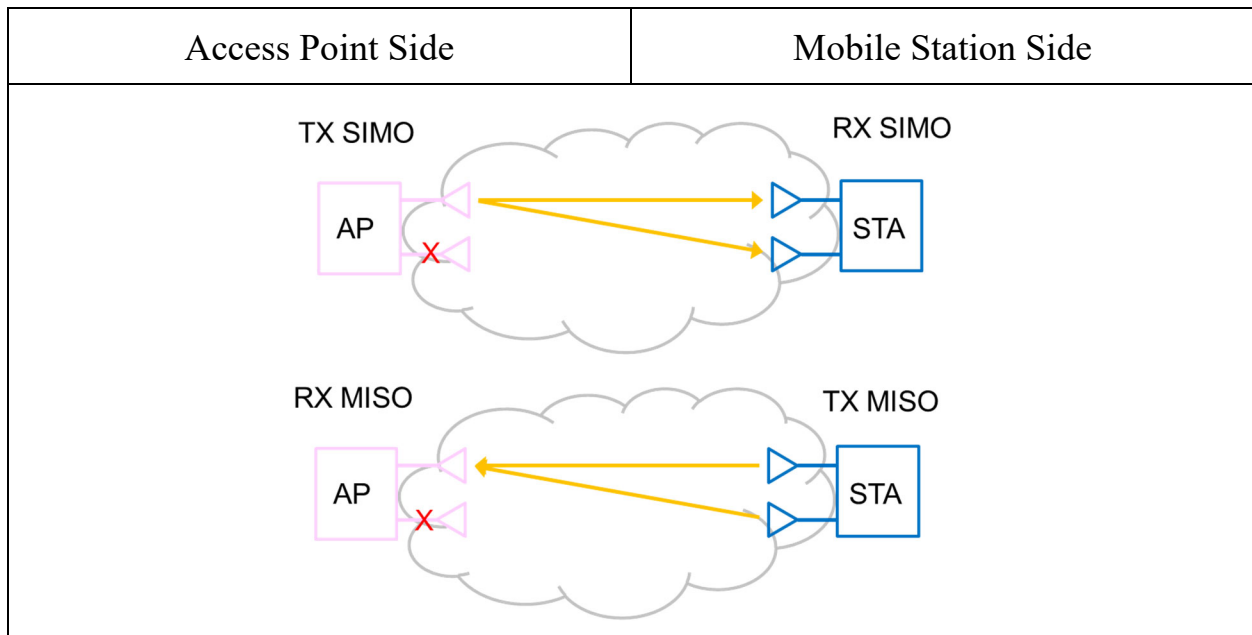
in both directions. These operating modes are depicted in the figure below, where “AP” stands for “access point” (the base station) and “STA” is the mobile station.

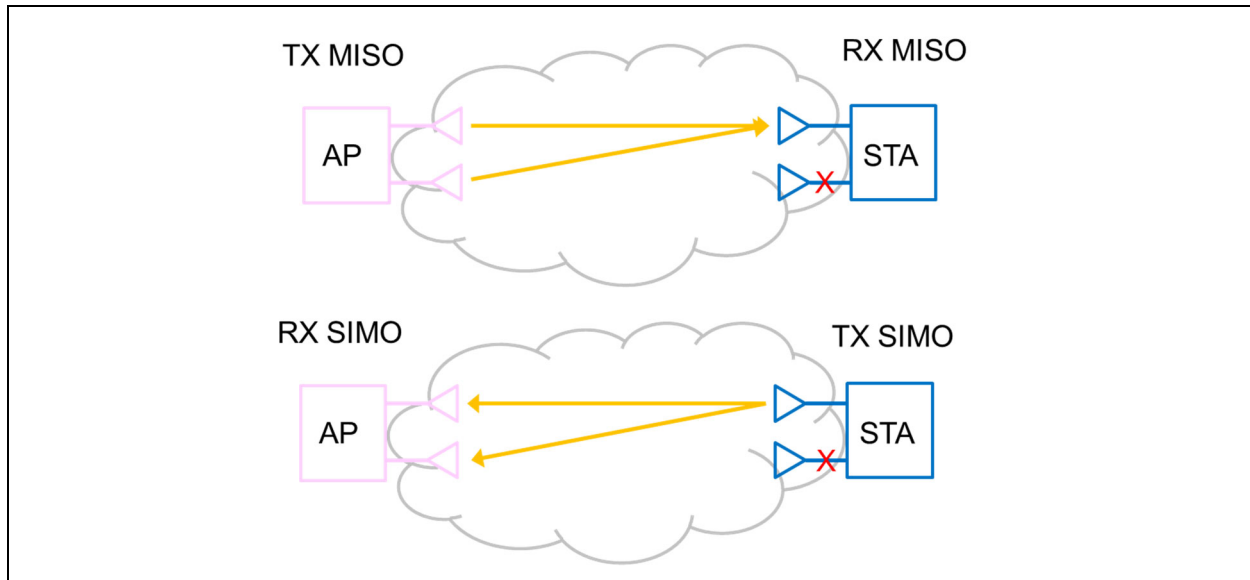


50. When one antenna is activated at one end of the communication link

⁴ “TX” is a well-known abbreviation for “transmit” or “transmitter,” and “RX” is a well-known abbreviation for “receive” or “receiver.”

and multiple antennas activated at the other end of the link, then communication will be SIMO in one direction and MISO in the other. For instance, if one antenna is activated at the base station and multiple antennas activated at the mobile station, then the downlink transmission from base station to mobile station is SIMO while the uplink transmission from mobile station to base station is MISO. On the other hand, if multiple antennas are activated at the base station and one antenna activated at the mobile station, then the downlink transmission from base station to mobile station is MISO while the uplink transmission from mobile station to base station is SIMO. These operating modes are shown in the figure below. *See, e.g., Ex-1034 (Molisch) at 46 (discussing SIMO, MISO, and MIMO operating modes); Ex-1031 (Walton) at ¶¶38-43.*





51. Using multiple antennas at either end of the wireless link often leads to performance enhancements through benefits known as spatial multiplexing and diversity. Spatial multiplexing increases data throughput by allowing multiple data streams to be transmitted simultaneously over the same frequency channel, effectively multiplying the channel's capacity. Diversity benefits improve signal quality and reliability by receiving the same signal through different paths, mitigating fading and enhancing overall connection stability. Together, these advantages generally lead to higher data rates and more robust wireless communication. *See, e.g., Ex-1035 (Chae) at 87 (discussing diversity, spatial multiplexing and a hybrid combination of these modes); see also, e.g., Ex-1034 (Molisch) at 46 (same).*

52. The advantages of using multiple antennas at the transmitter and/or receiver are significantly influenced by the *correlation* between the channels from

each transmit antenna to each receive antenna. Correlation is a measure of how similar or dissimilar these channels are. High correlation means the channels are very similar, while low correlation means they are dissimilar. It is generally more advantageous to have low correlation when multiple antennas are used. To illustrate this, consider two different systems: a 1-by-1 Single Input Single Output (SISO) system and a 2-by-1 Multiple Input Single Output (MISO) system. In a 1-by-1 SISO system, there is a single channel corresponding to the single transmit antenna that sends signals to the single receive antenna. In contrast, a 2-by-1 MISO system has two channels – one for each of the two transmit antennas that send signals to the common receive antenna. If the two channels in the MISO system are uncorrelated, meaning they have low correlation, they will be different. This provides a diversity advantage; if one channel is of poor quality, the other might be of good quality. Therefore, sending information over both channels increases the likelihood of successful transmission, as the system can leverage the channel that has better quality. Uncorrelated channels are also sometimes referred to as *orthogonal*. Conversely, if the channels are correlated, meaning they have high correlation, then if the first channel is of poor quality, the second channel will likely be poor as well. Having a pair of transmit antennas with highly correlated channels is no better than the 1-by-1 SISO system, where the single channel is also either good or bad at any given time. Hence, high correlation reduces the benefits of using multiple antennas.

53. When a mobile wireless device, such as a smartphone, transmits data, it consumes energy, depleting its battery. A significant source of power drain is the emission of signal energy from each transmit antenna. However, in producing the signal energy, additional power is also consumed by the circuit components associated with the device's transmitters, including radio-frequency (RF) amplifiers, filters, digital-to-analog converters, and oscillators. This additional energy is lost to heat. Each antenna is linked to a corresponding transmitter with its own circuitry, and it would have been well understood that using more antennas increases power consumption because a corresponding number of transmitters must be utilized. *See, e.g.,* Ex-1033 (Bougard) at 2. It was well-known by 2007 that circuit power consumption could influence whether one transmission mode should be selected over another. Ex-1033 (Bougard) at 2, 13-14.

54. The quality of a wireless link is quantified by the signal-to-noise ratio (SNR), which is the ratio of received signal power to the power of the noise. Achieving a desired performance, such as a specific user bit rate, requires that the SNR be above a certain minimum value. The received signal power is the transmit power reduced by the propagation losses of the channel, which depend on the distance between the transmitter and receiver. In a single-user system, the primary type of noise present is thermal noise, resulting from the random motion of electrons in the receiver's circuitry. In multi-user wireless networks, additional users can

create interference if they transmit simultaneously using the same channel resources.

This interference is often treated as an additional source of noise that is combined with the thermal noise. Increased interference raises the overall noise level, a phenomenon quantified by a value known as *noise rise*. Noise rise measures the amount of increased noise due to the presence of additional interfering users, and adding more users translates to a higher noise rise. An increase in noise rise decreases the SNR for a given received power. Since maintaining the desired performance requires the SNR to exceed a minimum value, an increase in noise rise increases the noise power and necessitates a corresponding increase in received signal power. For a fixed separation between the transmitter and receiver, this requires the transmitter to increase its transmit power, thereby increasing its power consumption. Accordingly, an increase in the number of users in the system will increase the power consumption of the transmitter.

55. Wireless networks typically utilize adaptive links, rather than fixed ones, to accommodate the dynamic nature of channel conditions, which are subject to impairments such as path loss, interference, and fading. *See, e.g.*, Ex-1036 (Ko) at 80 (discussing interference); Ex-1037 (Soysal) at 74 (discussing fading). To optimize performance, the network adjusts key parameters like the modulation and coding schemes, the transmission power, or the antenna configurations based on these fluctuating conditions. In some cases, the adaptation of transmission

parameters could result in turning on and off certain circuit blocks. The adaptation process is managed by a controller, a component situated within the base station and/or mobile station, which selects and modifies these crucial transmission parameters to ensure efficient communication. *See, e.g.*, Ex-1038 (Clark) at Abstract (“A power manager for the integrated circuit may manage the overall power consumption of the integrated circuit and may individually turn on and off the circuit blocks using the power gating circuits.”), ¶23 (“power manager 106 may operate as part of microprocessor 102A”); Ex-1039 (Tinnakornsriruphap) at ¶39 (“system 100 can utilize a centralized architecture by employing a system controller 130 that can be coupled to one or more base stations 110 and provide coordination and control for the base stations 110”); Ex-1031 (Walton) at ¶¶35-37 (“Power controller 230 generates the control signals for the various circuit blocks within wireless device 100 a. Power controller 230 obtains information indicating the operating state of wireless device 100 a (e.g., via user input or main controller 240) and generates the control signals accordingly.”).

56. When a wireless device is not actively transmitting or receiving data, it is said to be in an *idle* state. Even though it is not transmitting or receiving while idle, some of the circuits and processors in the wireless device remain on and therefore still consume power. It was well-known by 2007 that idle power consumption could influence whether one transmission mode should be selected

over another. Ex-1040 (Cui-2007) at 3690. For example, it was known that a node not transmitting or receiving data can wastefully consume energy and therefore it is beneficial to turn off all communications-related circuits for that node such that it can enter sleep mode to save energy. Ex-1040 (Cui-2007) at 3690 (“Energy Consumption”); *see also* Ex-1031 (Walton) at ¶¶53-66 (“In the Idle state, wireless device 100 may enable the desired number of receiver units via the control signals R_i for these receiver units. ... In the Sleep state, wireless device 100 may disable as many circuit blocks as possible in order to conserve power.”).

57. It was well-known by 2007 that the number of users in the system could influence whether one transmission mode should be selected over another. Specifically, in a multi-user system “the performance of each user depends not only on its own transmission, but also on the transmissions of the other users” such that “[a]s one user increases its power to improve its performance, it generates more interference and degrades the other users’ performance.” Ex-1030 (Chen) at 2700. It was known that allowing “each substream of each user to meet a signal-to-interference and noise ratio (SINR), while minimizing the sum transmit power, and therefore, mutual interference” was desirable. Ex-1030 (Chen) at 2700; *see also* Ex-1041 (Kim) at 6:9-17 (“[A] receiver selects at least one operating mode between MU-MIMO mode supporting multiple users and SU-MIMO mode supporting a single user, on the basis of the number of users.”); Ex-1042 (Hamdi) at 4038 (“When

there is a large number of users, the system performance can be significantly increased by selecting a subset of users and a set of receive antennas for each user.”).

58. Moreover, it was known that a crossover point on the transmission rate exists below which SIMO consumes less circuit power than MIMO. Ex-1033 (Bougard) at 2, 13-14; Ex-1044 (Lee) at 711 (“[I]t is not true that one transmission strategy always dominates the other. ... [T]here is a transition point – when the number of users is below this point, single user transmission outperforms multi-user transmission, and the reverse is true when the number of users exceeds this critical value.”).

VI. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS

A. Li (U.S. Patent Publication No. 2006/0067263) (Ex-1005)

59. Li, titled “Techniques to Manage Multiple Receivers,” was filed September 30, 2004 and published March 30, 2006. Ex-1005, Cover. I understand that Li is prior art under pre-AIA 35 U.S.C. §102(b) based on its publication date.

60. Li teaches a wireless communication system 100, depicted in Figure 1, which includes multiple “nodes” that communicate information, such as data or control information. Ex-1005 ¶¶9-10, Fig. 1. A “node” refers to any “physical or logical entity having a unique address” and could include a server, access point, cellular phone, or PDA, among others. *Id.* ¶9. Exemplary nodes also include wireless access point AP 110 (pink) and mobile stations STA 120 and STA 150 (blue), which

may be implemented as high throughput (HT) wireless devices and “may each include a MIMO system” having multiple transceivers and multiple antennas. Ex-1005 ¶¶12-13, 15, Fig. 1.

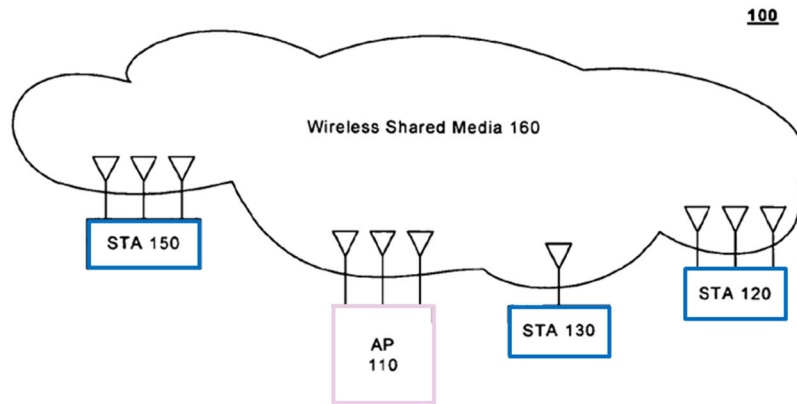
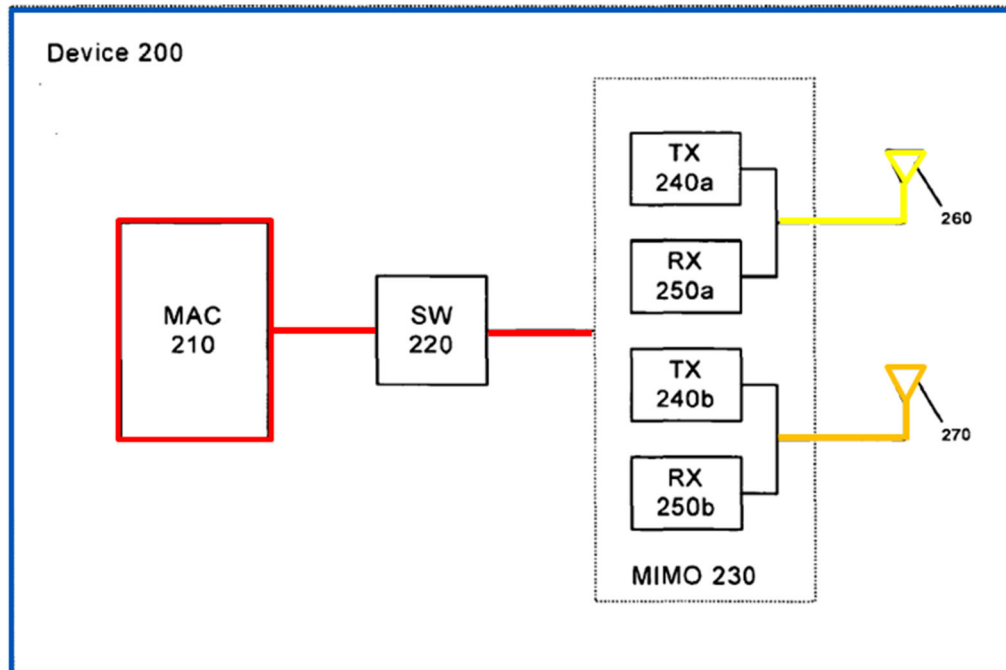


FIG. 1

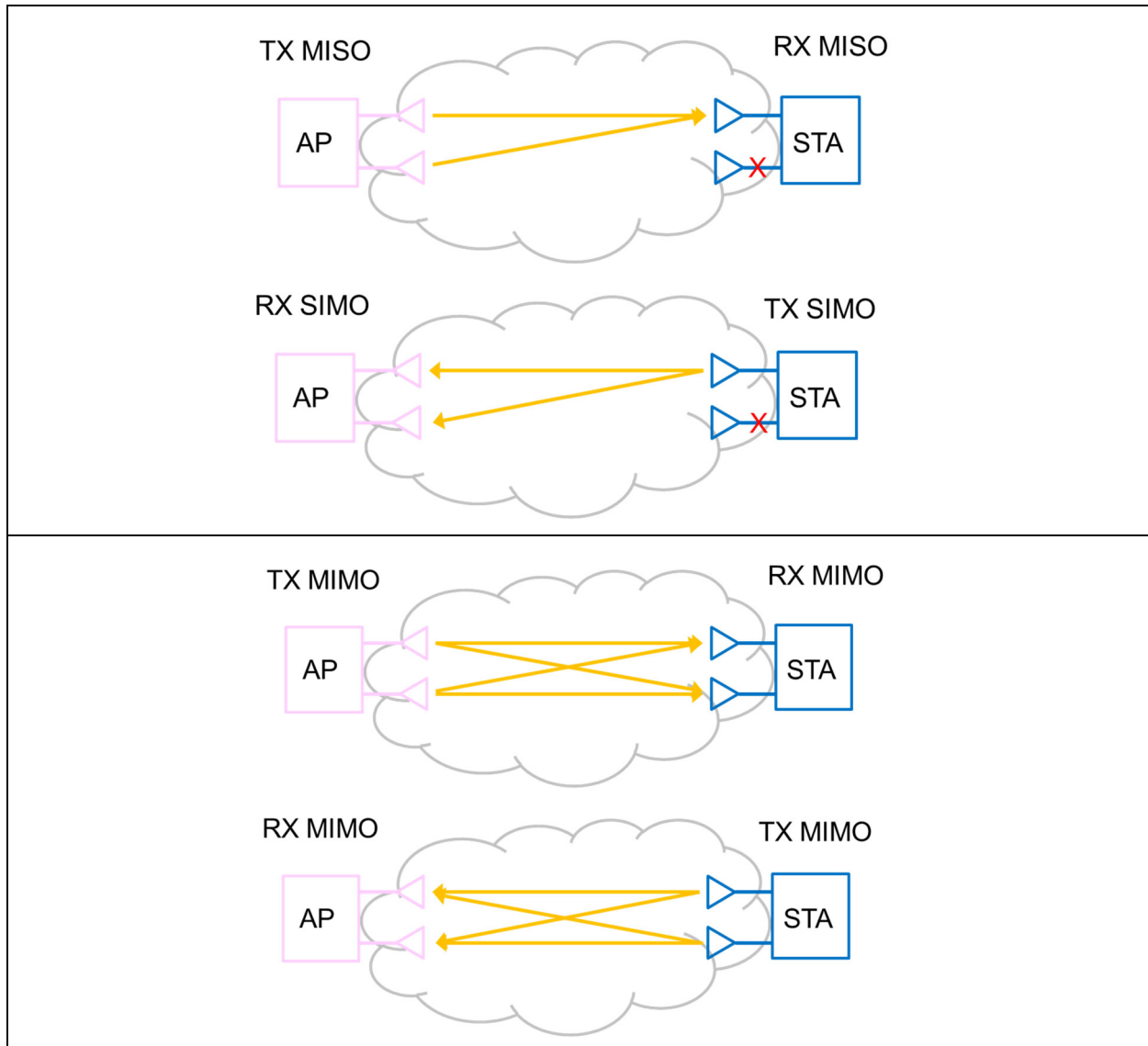
61. Li’s node 200 depicted in Figure 2 below (blue), representing mobile station STA 150, is configured to “operate in multiple operating modes” that activate one or multiple antennas, including SISO (single-input single-output), SIMO (single-input multiple-output), MISO (multiple-input single-output), and MIMO (multiple-input multiple-output). Ex-1005 ¶17.



62. Consistent with my Technical Background section (Section V), Li teaches that STA 150 can “operate in multiple operating modes” that enable one or multiple transmitter and receiver circuits, including:

In a SISO operating mode, a single transmitter and a single receiver may be used to communicate information signals over a wireless shared medium 160. In a MISO operating mode, two or more transmitters may transmit information signals over wireless shared media 160, and information signals may be received from wireless shared media 160 by a single receiver of a MIMO system. In a ***SIMO operating mode, one transmitter*** and two or more receivers may be used to communicate information signals over wireless shared media. In a ***MIMO operating mode, two or more transmitters*** and two or more receivers may be used to communicate information signals over wireless shared media 160.

Ex-1005 ¶17. These modes are the same modes illustrated in the simplified drawings that I provided in the Technical Background section (Section V) of this report.



63. Thus, when a mobile station (STA) is receiving, it can be in a SIMO or MIMO mode with two antennas active or in a SISO or MISO mode with one antenna active. *See* Ex-1005 ¶17. When a mobile station (STA) is transmitting, it can be in a MISO or MIMO mode with two antennas active or in a SISO or SIMO mode with one antenna active.

64. Li's Figure 2, above, depicts exemplary node 200 (blue), which may

represent any one of AP 110, STA 120 or STA 150 of Figure 1. Ex-1005 ¶20, Fig.

2. Node 200 includes multiple elements, such as media access control (MAC) processor 210 (red), switch (SW) 220, and transceiver array 230. Ex-1005 ¶20, Fig.

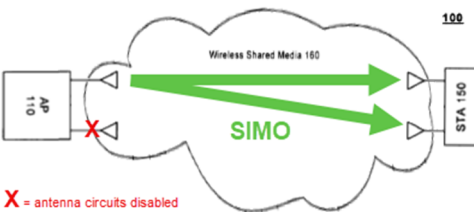
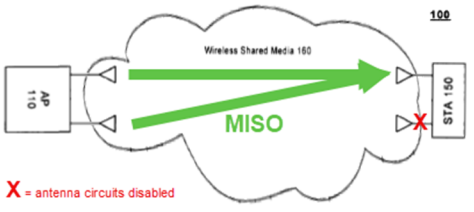
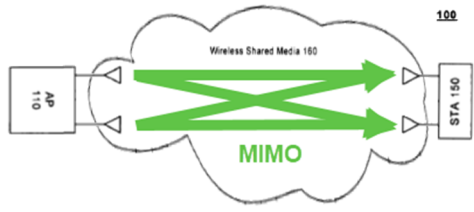
2. Node 200's elements may be implemented using "one or more circuits, components, registers, processors, software subroutines, or any combination thereof." *Id.* ¶20. Li further teaches that transceiver array 230 includes a first transmitter 240a/receiver 250a pair, which are coupled to antenna 260 (yellow), and a second transmitter 240b/receiver 250b pair, which are coupled to antenna 270 (orange). Ex-1005 ¶23, Fig. 2.

65. Li's MAC processor 210 "may be arranged to receive a physical layer convergence procedure (PLCP) protocol data unit (PPDU)." Ex-1005 ¶24. In a packet-based network, a PLCP PPDU is just a message with particular headers and a data payload that is sent to a node. The PPDU plays a key role in transmitting data over the air in a structured manner, ensuring proper synchronization, error detection, and data integrity. After receiving the PPDU message, "MAC 210 may output a receiver control signal in response to the received PPDU." Ex-1005 ¶24. The "receiver control signal may cause MIMO system 230 to switch between a first operating mode and a second operating mode in response to the receiver control signal." *Id.* The first and second operating modes are chosen from among the SISO, SIMO, MISO, and MIMO communication modes. *Id.* The operating modes define

how many antennas are used for transmitting (TX) (i.e., input to wireless shared media 160) and receiving (RX) signals (i.e., output from the wireless shared media 160). *See id.* ¶17. Thus, SISO refers to single input single output and can be depicted in my diagram (adapted from Li, Figure 1), where AP 110 is transmitting and STA 150 is receiving:



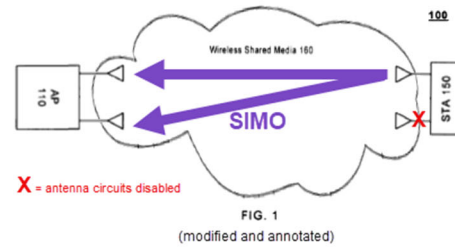
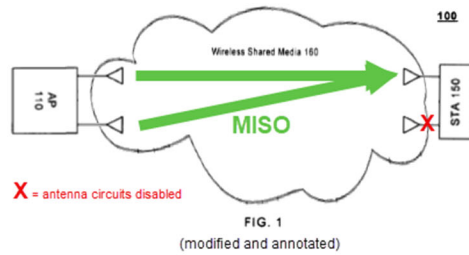
Ex-1005 ¶17 (“In a SISO operating mode, a single transmitter and a single receiver may be used to communicate information signals....”). Together, all four modes, SISO, SIMO, MISO, and MIMO, modes can be respectively depicted as follows, assuming AP 110 is transmitting:

	Single Output (SO)	Multiple Output (MO)
Single Input (SI)	 FIG. 1 (modified and annotated)	 FIG. 1 (modified and annotated)
Multiple Input (MI)	 FIG. 1 (modified and annotated)	 FIG. 1 (modified and annotated)

Ex-1005 ¶17. While this table depicts the four modes when AP 110 is transmitting and STA 150 is receiving (called the “downlink”), mobile STA 150 also transmits and AP 110 also receives (called the “uplink”). Ex-1005 ¶13 (“STA 120 and STA 150 may each include a MIMO system having *at least two transceivers* and two antennas.”).

66. When STA 150 becomes the transmitter, its active antennas can become the input(s), and AP 110’s active antennas can become the output(s), and correspondingly its mode would change. For example, when AP 110 is transmitting in MISO mode, it is transmitting two inputs to one output received at STA 150 (below, left), but when STA 150 responds it may transmit on one input to two outputs received at AP 110 (below, right), and in such case STA 150 is in SIMO mode. Ex-1005 ¶17 (“two or more transmitters may transmit ... over wireless shared media

160, ... and [] be received ... by a single receiver”).



This is only exemplary. The transmission mode could be MISO on the downlink and any of the four modes (SISO, MISO, SIMO, MIMO) on the uplink.

67. Li provides an example, from the point of view of a station's *receivers*, as to why such mode switching is beneficial for saving power:

For example, a station in idle mode waiting for *incoming* signals may consume approximately 60% of its battery energy. This inefficient use of energy may be exacerbated by MIMO devices, since more than one antenna may be turned on for *reception*. The power consumed by *low noise amplifiers and analog-to-digital converters* may be multiplied by the number of antennas.

Id. ¶18. This passage is talking about receiver operation because a low noise amplifier is a device that will amplify the weak received signal to a level suitable for further processing while an analog-to-digital converter will convert the received analog signal to a digital format, where it can be processed efficiently using a digital signal processor. Using the dynamic mode control feature of Li, a station can be switched from a mode with one *receiver* enabled (SISO or MISO) to one in which two or more *receivers* are enabled (MIMO), or vice versa:

When implemented as part of a station such as STA 120 and/or STA 150, node 200 may receive the request and switch MIMO system 230

from a SISO or MISO operating mode into a MIMO operating mode.
This may be accomplished by enabling two or more *receivers* from
MIMO system 230.

Id. ¶25. Having control over these modes allows power consumption to be optimized: “In this manner, power consumption for STA 120 and STA 150 may be reduced, thereby extending battery life for STA 120 and STA 150.” *Id.* ¶19. While Li discusses switching *receive* modes in this example, Li teaches that its “embodiments are not limited in this context.” Ex-1005 ¶24.

68. Although Li does not walk through the corresponding example for when the station is *transmitting*, a POSITA would have understood that the operation would be similarly taught by Li. In other words, and referring to the drawings illustrating the operational modes above, a POSITA would have understood from Li’s teachings that the dynamic control feature of Li would switch a station from a mode with one transmitter enabled (SIMO) to one with two or more transmitters enabled (MIMO), and vice versa. *See, e.g.*, Ex-1005 ¶¶19 (“STA 120 and STA 150 may acknowledge the request and may enable an operation of desired number of receivers and *transmitters* of the MIMO receivers-transmitters system.”), 17 (“In a *SIMO* operating mode, *one transmitter* and two or more receivers may be used to communicate information signals over wireless shared media. In a *MIMO* operating mode, *two or more transmitters* and two or more receivers may be used to communicate information signals over wireless shared media 160.”). Therefore,

in switching transmit modes between a mode in which one *transmit* antenna is enabled and a mode in which two or more *transmit* antennas are enabled, Li's system would be switching between a SIMO mode and a MIMO mode.

B. Siam (Mohammad Z. Siam et al., Adaptive Multi-antenna Power Control in Wireless Networks, International Conference on Wireless Communications and Mobile Computing 875-880 (2006)) (Ex-1006)

69. Siam, titled "Adaptive Multi-antenna Power Control in Wireless Networks," was presented at the International Conference on Wireless Communications and Mobile Computing held on July 3-6, 2006 in Vancouver, British Columbia, Canada, made available to the conference attendees on July 3, 2006, and published by the Association for Computing Machinery (ACM) on July 11, 2006. Ex-1022 (declaration); Ex-1024 (screenshot of website). My understanding/recollection of ACM conferences around 2003 was that they handed out the proceedings to attendees in the form of a CD. I understand that Siam is prior art under at least pre-AIA 35 U.S.C. §102(b) because both its presentation date and its ACM publication date are more than a year before the earliest priority date of the '120 Patent. In my opinion, Siam would have been readily available to a POSITA before the October 2007 priority date of the '120 Patent. For example, a POSITA would have been familiar with the ACM Digital Library in 2007 and understood how to use the Digital Library to search for relevant papers. To the extent Siam was published through the ACM Digital Library on July 3, 2006, as indicated by Ex-

1022 and Ex-1024, it would have been readily accessible to a POSITA as of at least that date.

70. Siam presents a protocol, called “E-BASIC,” which “is an extension of BASIC, a power-controlled MAC protocol that was originally developed for SISO-based ad-hoc networks.” Ex-1006, 876. The protocol dynamically adjusts “on a per-packet basis” the transmission power and transmission mode (e.g., SISO, SIMO, MISO, or MIMO) of data packets in a MIMO-capable wireless network having “two antennas per node,” in order to reduce the total energy consumption. Ex-1006, 875. Siam explains that “[w]hile the MIMO mode requires less RF transmission energy than the other three modes, it also incurs the highest circuit energy consumption.” Ex-1006, 875. Thus, “[d]epending on the transmitter-receiver distance,” any of the four modes could be “optimal” for “minimizing the total energy consumption.” Ex-1006, 875.

71. Accordingly, Siam develops a power model in which the “total power consumption consists of transmission and circuit powers.” Ex-1006, 876. Circuit power, P_c , is given by

$$P_c \approx M_t(P_{DAC} + P_{mix} + P_{filt}) + 2P_{syn} + M_r(P_{LNA} + P_{mix} + P_{IFA} + P_{filr} + P_{ADC}) \quad (2)$$

72. Here, Siam teaches that P_{DAC} , P_{mix} , P_{LNA} , P_{IFA} , P_{filt} , P_{filr} , P_{ADC} , and P_{syn} are power consumption values for the digital-to-analog converter (DAC), the mixer,

the low noise amplifier (LNA), the intermediate frequency amplifier (IFA), the active filters, the analog-to digital converter (ADC) and the frequency synthesizers. Ex-1006, 877. This circuit power model is folded into Siam's E-BASIC protocol, which seeks to determine "an optimally chosen multi-antenna scheme (among SISO, SIMO, MISO, or MIMO) according to the total power consumption that each scheme results." Ex-1006, 877.

C. Cui-2003 (Shuguang Cui et al., Modulation Optimization Under Energy Constraints, 4 Institute of Electrical and Electronic Engineers International Conference on Communications 2805-2811 (2003)) (Ex-1007)

73. Cui-2003, titled "Modulation Optimization Under Energy Constraints," was presented at the 2003 IEEE International Conference on Communications (ICC) held on May 11-15, 2003 in Anchorage, Alaska, USA, and published by the Institute of Electrical and Electronic Engineers ("IEEE") on June 11, 2003. Ex-1023 (declaration attaching a screenshot of website as Exhibit A). I personally attended this conference and co-authored a paper at the same conference that was presented by my student. While I cannot recall if I attended the presentation of the Cui-2003 paper, I still have in my possession the conference proceedings, which were provided to all attendees on a compact disk (CD) when they checked in at the start of the conference. I can attest that this paper is included on that CD. Ex-1032 (screenshots from my CD). I understand that Cui-2003 is prior art under at least pre-AIA 35 U.S.C. §102(b) because both its presentation date and its IEEE publication date are

more than a year before the earliest priority date of the '120 Patent. In my opinion, Cui-2003 would have been readily available to a POSITA before the October 2007 priority date of the '120 Patent. For example, a POSITA would have been familiar with the IEEE website in 2007 and understood how to use the IEEE website to search for relevant papers. To the extent Cui-2003 was published through the IEEE website on June 11, 2003, as indicated by Ex-1023, it would have been readily accessible to a POSITA as of at least that date.

74. Cui-2003 teaches methods for selecting “the best modulation strategy to minimize the total energy consumption” in a wireless transceiver network while meeting data throughput and delay requirements. Ex-1007, 2805. For example, Cui-2003 teaches that “to find the optimal transmission scheme, the overall energy consumption including both transmission and circuit energy consumption needs to be considered.” Ex-1007, 2805.

75. Cui-2003's Figures 1 and 2 depict “signal paths on the transmitter and receiver sides.” Ex-1007, 2806, Figs. 1-2. Cui-2003 considers the power consumption of the circuitry coupled to the antennas in active mode, sleep mode, and during transitions back to active mode. Ex-1007, 2806.

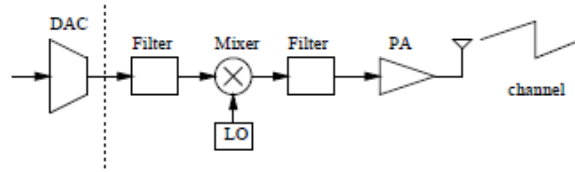


Fig. 1. Transmitter Circuit Blocks (Analog)

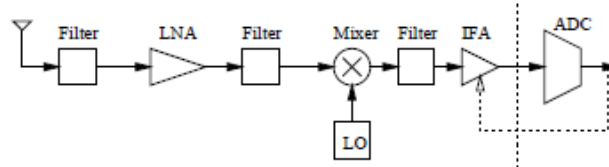


Fig. 2. Receiver Circuit Blocks (Analog)

76. Specifically, Cui-2003 “assume[s] that the transceiver circuitry works on a multimode basis” such that “when there is a signal to transmit all circuits work in active mode, when there is no signal to transmit they work in sleep mode, and when switching from sleep mode to active mode there is a transient mode.” Ex-1007, 2806. This “multi-mode operation” allows significant energy to be saved when the sleep mode is used. Ex-1007, 2806.

D. Tirola (Esa Tirola and Juha Ylitalo, Performance of a UMTS Uplink MIMO Scheme, 1 Institute of Electrical and Electronic Engineers 58th Vehicular Technology Conference 657-661 (2003)) (Ex-1008)

77. Tirola, titled “Performance of a UMTS Uplink MIMO Scheme,” was presented at the Fall 2003 IEEE Vehicular Technology Conference (VTC) on October 6-9, 2003 in Orlando, Florida, USA, and published by the IEEE on May 4, 2004. Ex-1023 (declaration attaching a screenshot of the website as Exhibit B). I

personally attended this conference and co-authored a paper at the same conference that was presented by my student. While I cannot recall if I attended the presentation of the Tirola paper, I still have in my possession the conference proceedings, which were provided to all attendees on a compact disk (CD) when they checked in at the start of the conference. I can attest that this paper is included on that CD. Ex-1043 (screenshots from my CD). I understand that Tirola is prior art under at least pre-AIA 35 U.S.C. §102(b) because both its presentation date and its IEEE publication date are more than a year before the earliest priority date of the '120 Patent. In my opinion, Tirola would have been readily available to a POSITA before the October 2007 priority date of the '120 Patent. For example, a POSITA would have been familiar with the IEEE website in 2007 and understood how to use the IEEE website to search for relevant papers. To the extent Tirola was published through the IEEE website on May 4, 2004, as indicated by Ex-1023, it would have been readily accessible to a POSITA as of at least that date.

78. Tirola studies uplink (UL) performance in a mobile telecommunications system assuming different SIMO and MIMO transmission approaches from mobile stations having a maximum of two transmit antennas to base stations having up to four antennas. Ex-1008, 657. Figure 1 depicts a “block diagram of the considered SIMO [] and MIMO transmission schemes.” Ex-1008, 657, Fig. 1.

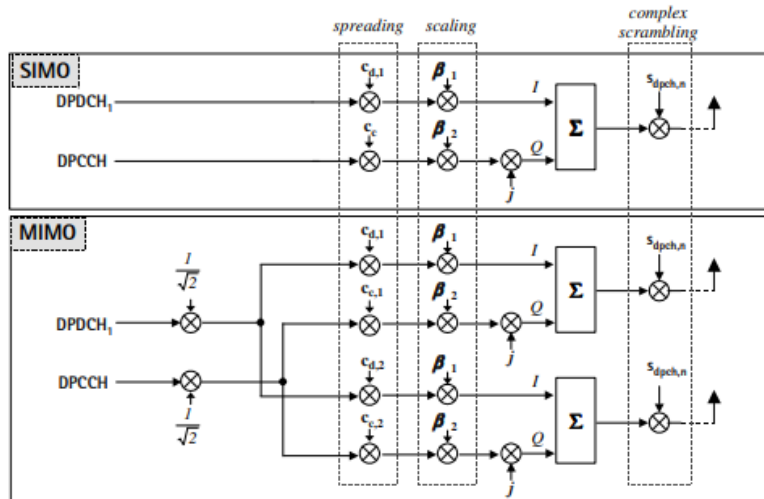
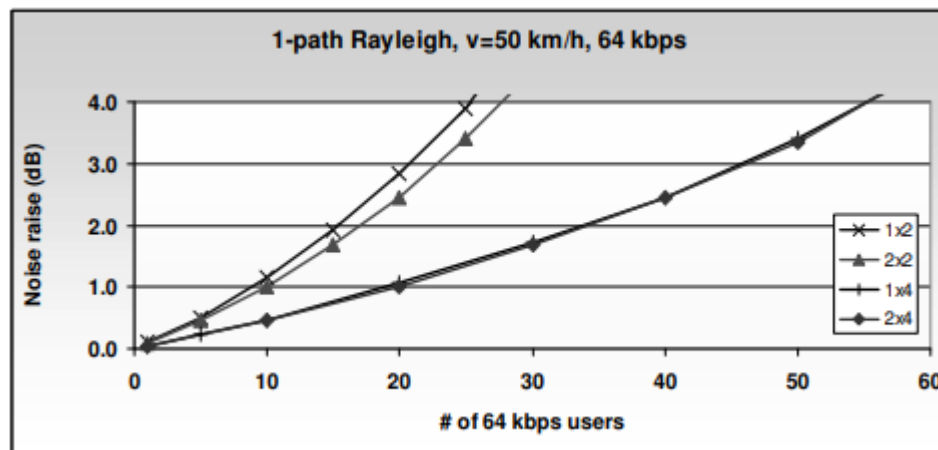


Figure 1. Block diagram of the considered transmission schemes.

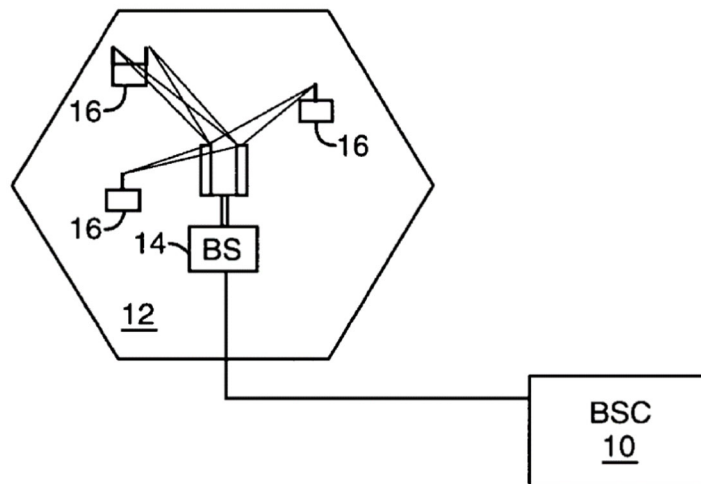
79. Tirola calculates and simulates the effects of the number of users (J) on uplink performance. Ex-1008, 658. Tirola also calculates the increase in noise from the UL load factor based on the number of users for various antenna configurations. Ex-1008, 658. Tirola's simulation of noise rise, depicted in Figure 4(b), demonstrates that noise rise is larger for a 1x2 (SIMO) mode than for a 2x2 (MIMO) mode and the advantage of a MIMO mode increases with increasing number of users. Ex-1008, 659-61, Fig. 4(b).



E. Wu (U.S. Patent Publication No. 2007/0171808) (Ex-1009)

80. Wu (U.S. Pat. Pub. 2007/0171808) was filed January 20, 2006 and published July 26, 2007. I understand that Wu is prior art under at least pre-AIA 35 U.S.C. §102(b).

81. Wu teaches a scheduling algorithm for a virtual cooperative MIMO system. Ex-1009, Abstract, ¶5. Figure 1 depicts Wu's "wireless communication environment," which includes a base station BS 14 and a number of mobile terminals 16 that have one or more antennas. Ex-1009 ¶¶11, 24.



82. Wu's system evaluates several factors to determine how the mobile terminals will communicate with the base station. *See, e.g.*, Ex-1009 ¶71. If the mobile terminals are moving very quickly, Wu's base station assumes that the channel is changing too rapidly and randomly schedules the mobile stations to a Random User Scheduling (RUS) group. Ex-1009 ¶73. But if the mobile terminals

are moving more slowly, Wu's base station picks one mobile device and then looks for another one such that their channels are the most orthogonal and organizes them into a virtual MIMO system to communicate with the base station in a MIMO mode (this is called channel aware orthogonal scheduling, or CAOS). Ex-1009 ¶74. It then proceeds to the next device and finds its most orthogonal pair device and sets up another virtual MIMO link with them. Ex-1009 ¶76. Wu further teaches that if a certain device has poor channel quality, the system instead just sets up a SIMO link for that device to communicate to the base station individually. Ex-1009 ¶75. For example, if a mobile terminal lacks orthogonality with another mobile terminal, then the mobile terminal will rarely, and potentially, never be paired with another mobile terminal to form a virtual MIMO link. Ex-1009 ¶68. As I explained above, a POSITA would have recognized that this lack of orthogonality with another mobile terminal is due to the mobile station's channel having high correlation with the channels of the other mobile stations and that this will result in the selection of a SIMO link for this mobile station (*see* Section V). Wu explains the well-known relationship that channels that are highly orthogonal to one another have very low correlation. Ex-1009 ¶56. A channel exhibiting "poor channel quality" results in selection of a SIMO mode. Ex-1009 ¶75, Fig. 12 (flowchart illustrating this concept).

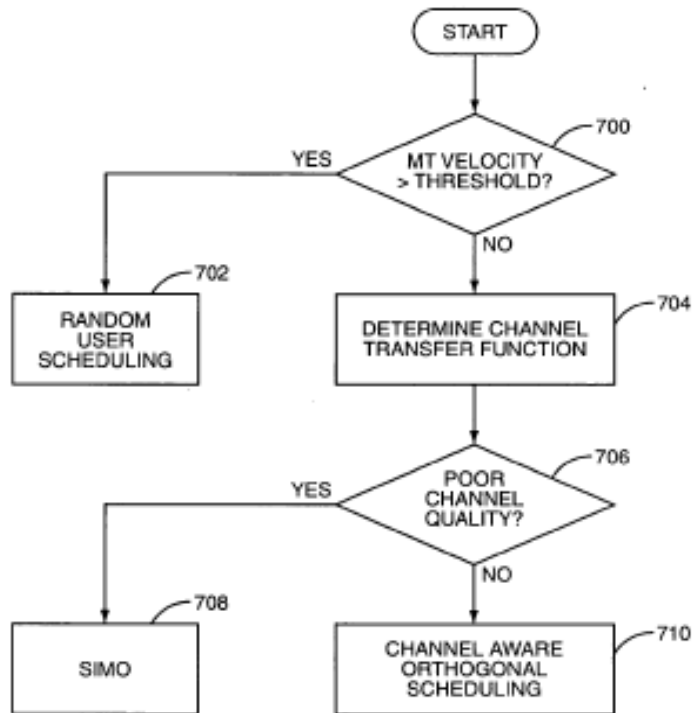


FIG. 12

VII. CLAIM CONSTRUCTION

83. I do not believe that any claim term requires explicit construction to resolve the issues presented in this Petition. I apply the plain and ordinary meaning to each claim term, as that plain and ordinary meaning would have been understood by a POSITA.

84. I respectfully reserve the right to offer opinions on any claim constructions proposed in this proceeding or to offer opinions on additional constructions in the district court.

VIII. DETAILED EXPLANATION OF THE UNPATENTABILITY GROUNDS

A. Ground 1: Claims 25, 27, and 28 Are Obvious Over Li In View of Siam

1. A POSITA would have been motivated to combine Li's teachings with Siam's teachings and would have had a reasonable expectation of success

85. A POSITA would have been motivated to combine Li and Siam (“Li-Siam”), and would have had a reasonable expectation of success in doing so, because both describe systems that select an optimal data communication mode in a wireless communication system, from among SISO, MISO, SIMO, and MIMO modes, in order to reduce the total energy consumption of the system. Ex-1005 ¶¶18 (“One problem associated with wireless communication devices ... is power consumption.”), 19 (“Some embodiments may solve this and other problems. ... For example, AP 110 operating in a MISO or a SISO operating mode may send a request over wireless shared media 160 to switch STA 120 and STA 150 to a SIMO or MIMO operating mode, if desired. ... In this manner, power consumption for STA 120 and STA 150 may be reduced, thereby extending the battery life for STA 120 and STA 150.”); Ex-1006, 875 (“[W]e propose a power-controlled channel access protocol ... where we dynamically adjust the ‘transmission mode’ and the transmission power on a per-packet basis so as to minimize the total energy consumption. By ‘transmission mode’ we mean one of the four possible transmit/receive antenna configurations” SISO, MISO, SIMO, and MIMO).

86. As discussed below, Li's system receives a PPDU message (i.e., a network message) and outputs a control signal in response. Ex-1005 ¶24. The control signal causes the mobile station to switch from a first communication mode (for example, MIMO), to a second communication mode, (for example, MISO), within a MIMO-capable system. Ex-1005 ¶¶24-25 ("An example of the first operating mode may include a SIMO operating mode and a MIMO operating mode. Examples of the second operating mode may include a SISO operating mode and a MISO operating mode."). Li also expressly addresses idle power consumption of the receiver, noting that "a station in *idle mode* waiting for incoming signals may consume approximately 60% of its battery energy." Ex-1005 ¶18.⁵ This is an "inefficient use of energy" that is worsened in MIMO devices because "more than one antenna may be turned on for reception." Ex-1005 ¶18. Li explains that the mode selection is intended to reduce power consumption, thereby extending the battery life of the mobile stations. Ex-1005 ¶19.

87. The example presented in Li at paragraphs 21-25 teaches switching the receive mode of the mobile station STA 150, enabling two receive antennas and

⁵ Idle power consumption means that the circuits are powered but have nothing to transmit or receive. For example, the '120 Patent explains that "idle time is a time during which the transceiver may be waiting to send data over the communications channel. The transceiver may, for example, be waiting for a scheduled start time for the transceiver to use the communications channel." Ex-1001, 2:60-64. On the receiver side, idle power consumption means that the circuits are powered but have nothing to receive.

circuits, and also teaches enabling any number of transmitters as well, such that mobile STA 150 could be switched, for example, from a transmit SIMO to a transmit MIMO mode, as explained below when applying Li-Siam to Element 25[d]. Section VIII.A.2.e.

88. Li teaches that the “embodiments are not limited in this context.” Ex-1005 ¶¶24-25. However, as explained above, STA 150 also transmits and AP 110 also receives. Ex-1005 ¶15. Conceptually, AP 110 and STA 150 both share the node 200 architecture shown in Figure 2. Ex-1005 ¶20.

89. Li further explains that when its MAC receives the control signal, “STA 150 may acknowledge the request and may enable an operation of desired number of receivers and *transmitters* of the MIMO receivers-transmitters system.” *Id.* ¶19. Regardless, such an optimization would have been obvious in view of Siam.

90. Siam complements Li by expressly teaching a protocol (called E-BASIC) for switching the *transmit* mode of a MIMO-capable system between using a single transmit antenna (e.g., SIMO) and using multiple transmit antennas (e.g., MIMO) to reduce total energy consumption. Ex-1006, 875. Like Li’s mode switching scheme, Siam’s E-BASIC protocol is also based on a multiple access (MAC) protocol. Ex-1006, 876. While both Li and Siam switch modes to reduce power consumption, Siam’s protocol expressly takes into consideration both radio frequency (RF) transmission power (i.e., what is radiated) and circuit power

consumption (i.e., what is dissipated as heat). Ex-1006, 875-76. For example, Siam teaches that “[w]hile the MIMO mode requires less RF transmission energy than the other three modes, *it also incurs the highest circuit energy consumption.*” Ex-1006, 875. Thus, a tradeoff between transmit power and circuit power consumption for particular network characteristics, such as data speeds and distances, is necessary to select the optimal mode. Ex-1006, 875-76. Furthermore, Siam expressly teaches selecting between SIMO and MIMO in transmission modes. Ex-1006, 875-76.

91. A POSITA would have been motivated to improve Li’s mode-switching system by adding Siam’s teaching that expressly considers both RF transmit power and circuit power consumption to select an optimal transmit mode between SIMO and MIMO (or SISO and MISO) at the mobile station to minimize battery power consumption. Li already teaches using “its battery energy for communicating actual traffic.” Ex-1005 ¶18. In the combined Li-Siam system, Li’s PPDU message (a control signal) received by Li’s MAC 210 for switching receiver communication modes would also be based on Siam’s teaching that both transmission power and circuit power should be considered when selecting the optimal communication mode, because both references seek to optimize power consumption and preserve battery life. Additionally, it would ensure a more efficient system because the mobile station would be able to use more “of its battery energy for communicating actual traffic.” Ex-1005 ¶18.

92. A POSITA would have had a reasonable expectation of success in combining the teachings of Li and Siam because they teach compatible systems—namely, electronic devices operating in accordance with IEEE 802.11 standard protocols or other data communications standards for wireless communication systems. Ex-1005 ¶¶15 (“STA 120 and STA 150 may each include a MIMO system having at least two transceivers and two antennas.”), 18-19, 20 (“Some elements may be implemented using, for example, one or more circuits, components, registers, processors, software subroutines, or any combination thereof.”), 21-23, 24 (“MAC 210 may output a receiver control signal in response to the received PPDU. The receiver control signal may cause MIMO system 230 to switch between a first operating mode and a second operating mode between SISO, SIMO, MISO, and MIMO in response to the receiver control signal.”), 25; Ex-1006, 875 (“Our energy model accounts for both transmission and the circuit powers.”), 876 (“[E]ach node is equipped with two antennas.”), 877, 878 (“The networks in this scenario are based on the infrastructure mode, which means that there is a centralized AP that can communicate with all other nodes while all other nodes can only communicate with the AP.”). Additionally, Li and Siam each purport to solve the problem of inefficient power consumption in wireless communication devices in similar and predictable ways, namely, by selecting and/or switching to an optimal transmission mode to reduce total power consumption and improve overall system performance. Ex-1005

¶19; Ex-1006, Abstract. A POSITA would have understood that their teachings could be combined with little to no change in their respective functions.

2. Independent Claim 25

a. Element 25[pre]: A mobile station for use in a communications system comprising:

93. Li-Siam teaches or suggests Claim 25’s preamble, to the extent it is limiting. Li teaches a wireless communication system 100, depicted in Figure 1, which includes multiple nodes that communicate information, such as media and control information. Ex-1005 ¶¶9-10, Fig. 1. Exemplary nodes include wireless access point AP 110 (pink) and mobile stations STA 120 and STA 150 (blue), which “may each be implemented as, for example, a wireless communication device, such as mobile or cellular telephone.” Ex-1005 ¶14. STA 150, for example, is a mobile station for use in a communication system.

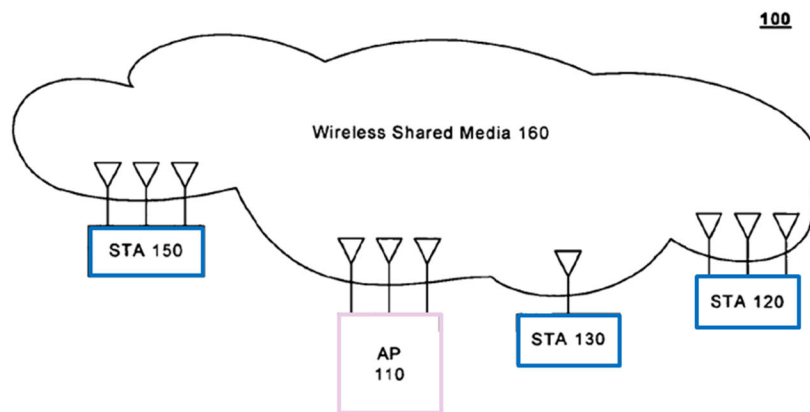


FIG. 1

b. Element 25[a]: a first antenna and a second antenna;

94. Li-Siam teaches or suggests Element 25[a]. Li's system 100 includes mobile station STA 150 (blue), which may be implemented as an HT wireless devices such as "[a] mobile or cellular telephone" and "may ... include a MIMO system having at least two transceivers and two antennas." Ex-1005 ¶¶13, 15, Fig. 1.

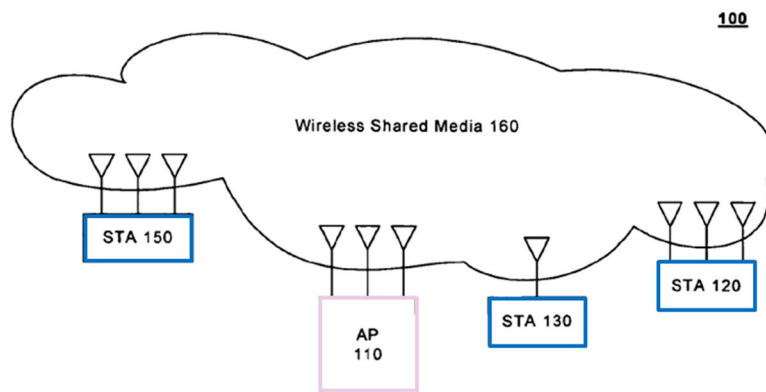
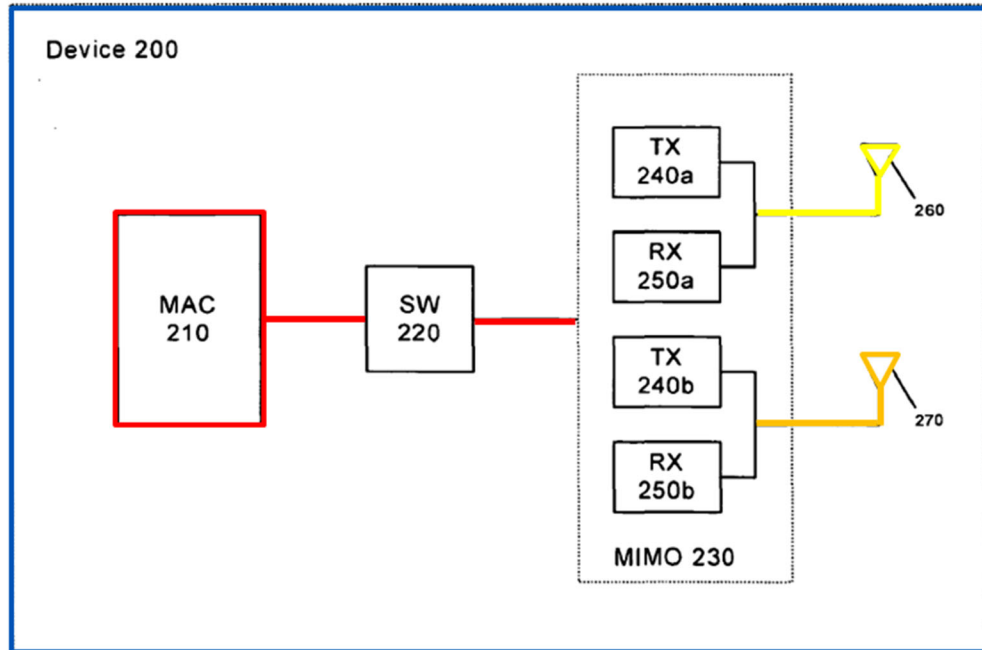


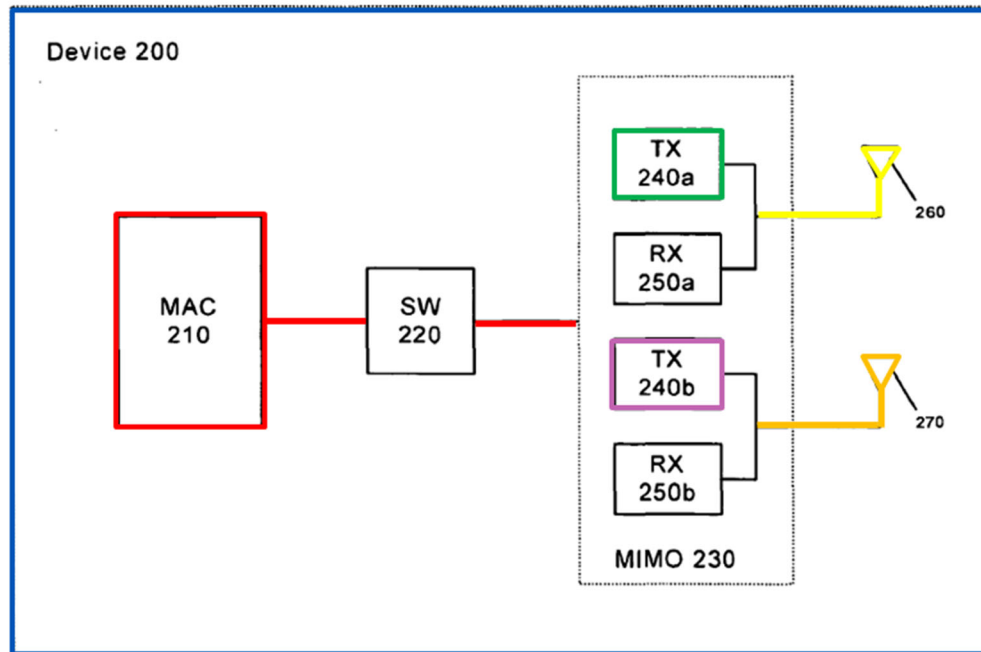
FIG. 1

95. Li's exemplary node 200 (blue), depicted in Figure 2, represents mobile station STA 150. Ex-1005 ¶20, Fig. 2. The mobile station STA 150 includes a first antenna 260 (yellow) and a second antenna 270 (orange). Ex-1005 ¶23, Fig. 2. First antenna 260 is coupled to transmitter 240a/receiver 250a in transceiver array 230, and second antenna 270 is coupled to transmitter 240b/receiver 250b, also in transceiver array 230. Ex-1005 ¶23, Fig. 2.



- c. **Element 25[b]: first circuitry coupled to the first antenna and configured to process signals for transmission by the first antenna; second circuitry coupled to the second antenna and configured to process signals for transmission by the second antenna; and**

96. Li-Siam teaches or suggests Element 25[b]. Li's first and second antennas are coupled to first and second circuitry that processes signals for transmission by the respective antennas. In Figure 2, shown below, node 200 (blue), representing mobile station STA 150, includes transmitter circuitry 240a (green) that is "operatively coupled" to first antenna 260 (yellow) and transmitter circuitry 240b (purple) that is "operably coupled" to second antenna 270 (orange). Ex-1005 ¶¶21, 23; Fig. 2.



97. Li's "transmitters 240a-b ... may be implemented as Orthogonal Frequency Division Multiplexing (OFDM) transmitters" and "may communicate data frames with other wireless devices." Ex-1005 ¶22. The "data frames may be modulated in accordance with a number of modulation schemes, to include Binary Phase Shift Keying (BPSK), Quadrature Phase-Shift Keying (QPSK)," and others. *Id.* A POSITA would have understood that in order to modulate data and communicate data frames using OFDM, transmitters 240a and 240b would include circuitry "configured to process signals" for transmission through the antennas to which they are "coupled." Moreover, Li teaches that node 200's elements may be implemented, for example, using "one or more circuits, components, registers, processors, software subroutines, or any combination thereof." Ex-1005 ¶20; *see*

also id., ¶¶52-56. It would have been recognized by a POSITA that both transmitter 240a and transmitter 240b would necessarily include circuitry whose purpose is to process signals for transmission. A POSITA would have further recognized that such circuitry would include common component such as digital-to-analog converters, filters, mixers, and power amplifiers.

98. Moreover, a POSITA would have understood that the first and second circuitry process signals for transmission by the first and second antenna because Li teaches that “wireless communication devices with multiple antennas may include a [MIMO] modulation and/or coding system to control receiving and transmitting of RF signals through multiple antennas.” Ex-1005 ¶1. Figure 2 clearly shows that each of transmitter 240a and transmitter 250b are connected to a separate antenna, numbered 260 and 270, respectively. It would have been understood by a POSITA that the purpose of connecting each transmitter to its own antenna is to support simultaneous transmission by the antennas, i.e., to support MIMO and/or MISO modes of operation.

d. Element 25[c]: a controller coupled to the first and second circuitry, wherein the controller is configured to receive a control signal and,

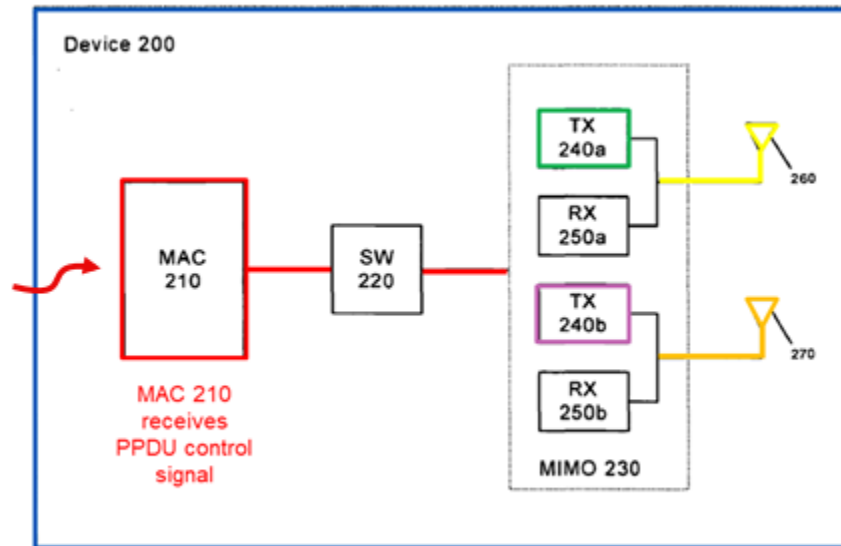
99. Li-Siam teaches or suggests Element 25[c]. Li teaches a controller coupled to the first and second circuitry of mobile station STA 150, wherein the controller is configured to receive a control signal which may be sent by access point

AP 110. Ex-1005 ¶¶27, 30. Media Access Control (MAC) processor 210 (“a controller” (red)⁶) of node 200 (blue) is configured to receive a PPDU⁷ (the claimed “control signal”) and “output a receiver control signal in response to the received PPDU.” Ex-1005 ¶24, Fig. 2. Although the example in paragraph 24 refers to the PPDU message as a “receiver control signal,” elsewhere Li teaches that “STA 150 may acknowledge the request [from AP 110] and may *enable an operation of desired number of receivers and transmitters* of the MIMO receivers-transmitters system.” Ex-1005 ¶19. Thus, while the specific example refers to receiving a receiver control signal, a POSITA would have understood that STA 150’s controller MAC 210 would also have been configured to receive (and acknowledge) control signals that would also enable the specified number of transmitters. To receive a request from AP 110 to enable the desired number of transmitters, and acknowledge it, is referring to the number of transmitters at mobile station STA 150 because MAC 210 can only control the circuits it is coupled to, including transmitters 240a and

⁶ Elsewhere Li refers to the MAC as the “media access controller” (see Ex-1005, claim 1), suggesting to a POSITA that the closely related terms controller and processor are being used interchangeably. Li also notes that its embodiments could be implemented in any suitable form including: processors, computers, and processing devices, etc. (Ex-1005 ¶58), which a POSITA would have understood to include controllers.

⁷ As I discussed in my background section on Li, “a PLCP PPDU is just a message with particular headers and a data payload that is sent to a node. The PPDU plays a key role in transmitting data over the air in a structured manner, ensuring proper synchronization, error detection, and data integrity.” Section VI.A.

240b.

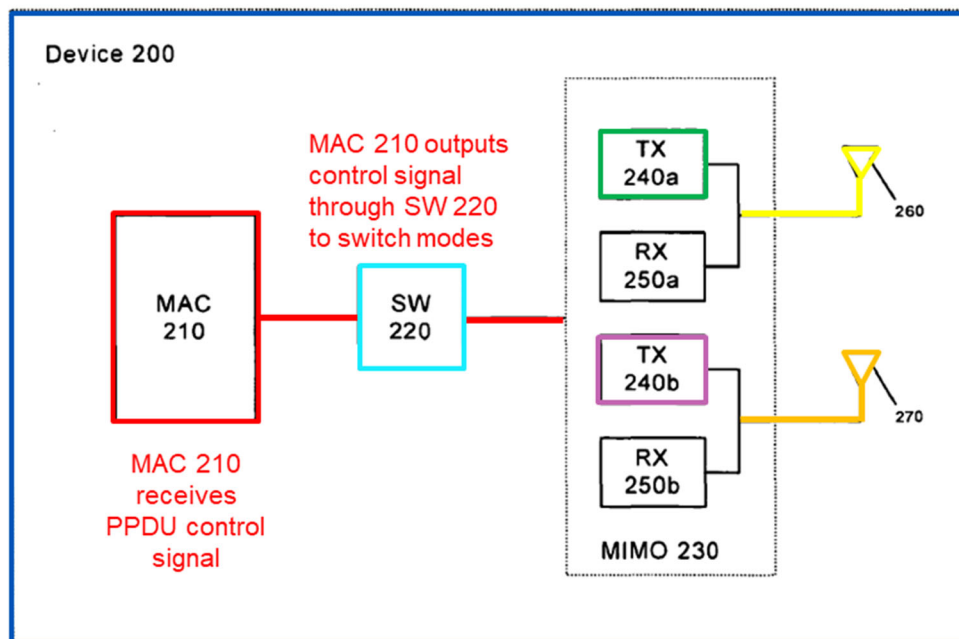


100. A POSITA would have understood that in order to output a signal to switch the communication mode, MAC processor 210 would need to be coupled to switch 120 and thence to the first and second circuitry, which are further coupled to the first and second antenna, because Li teaches that “wireless communication devices with multiple antennas may include a [MIMO] modulation and/or coding system to control receiving and transmitting of RF signals through multiple antennas.” Ex-1005 ¶1. Moreover, Li teaches that node 200’s elements may be implemented, for example, using “one or more circuits, components, registers, processors, software subroutines, or any combination thereof.” Ex-1005 ¶20. It would have been recognized by a POSITA that MAC processor 210 would be implemented as a control processor (i.e., controller) running logic embodied for instance as software or firmware routines. Moreover, as the MAC processor’s output

is in response to the receive PPDU (Ex-1005 ¶24), it would have been understood by a POSITA that the PPDU is a control signal that is received by the MAC processor.

- e. **Element 25[d]: in accordance with the control signal, to select between a multiple-input multiple-output (MIMO) mode wherein both the first and second antennas transmit data over a communications channel and a single-input multiple-output (SIMO) mode wherein only one of the first and second antennas transmit data over a communications channel,**

101. Li-Siam teaches or suggests Element 25[d]. As explained for Element 25[c], Li teaches that the control signal output by MAC processor 210 (red) in response to receiving the PPDU message, outputs a control signal to cause the system “to switch between a first operating mode” and “a second operating mode,” using switch 220 (teal). Ex-1005 ¶¶19, 24-25, Fig. 2.



102. Li describes an example where “the first operating mode may include a SIMO operating mode and a MIMO operating mode. Examples of the second operating mode may include a SISO operating mode and a MISO operating mode. The embodiments are not limited in this context.” Ex-1005 ¶24. In this non-limiting example, the switch from first mode to second mode is SIMO → SISO or is MIMO → MISO, which is controlling the number of receivers at the mobile STA 150 (i.e., the downlink).

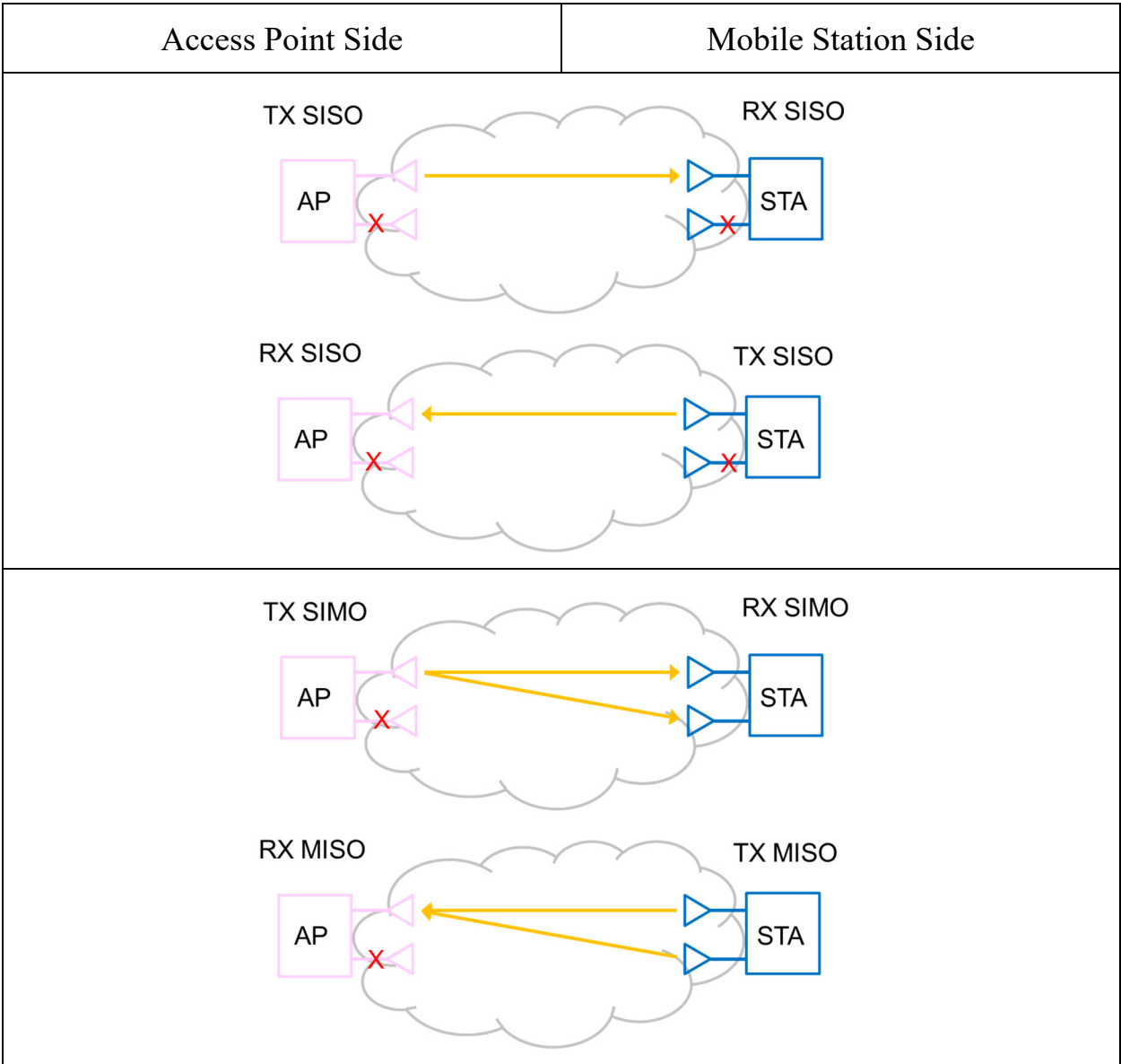
103. Li’s node 200 (blue), representing mobile station STA 150, is configured to “operate in multiple operating modes” that activate one or multiple antennas, including (1) SISO (single-input single-output), (2) SIMO (single-input multiple-output), (3) MISO (multiple-input single-output), and (4) MIMO (multiple-input multiple-output). Ex-1005 ¶17. Of these, *SISO* and *SIMO* use one transmitter and *MISO* and *MIMO* use two transmitters. Ex-1005 ¶17.

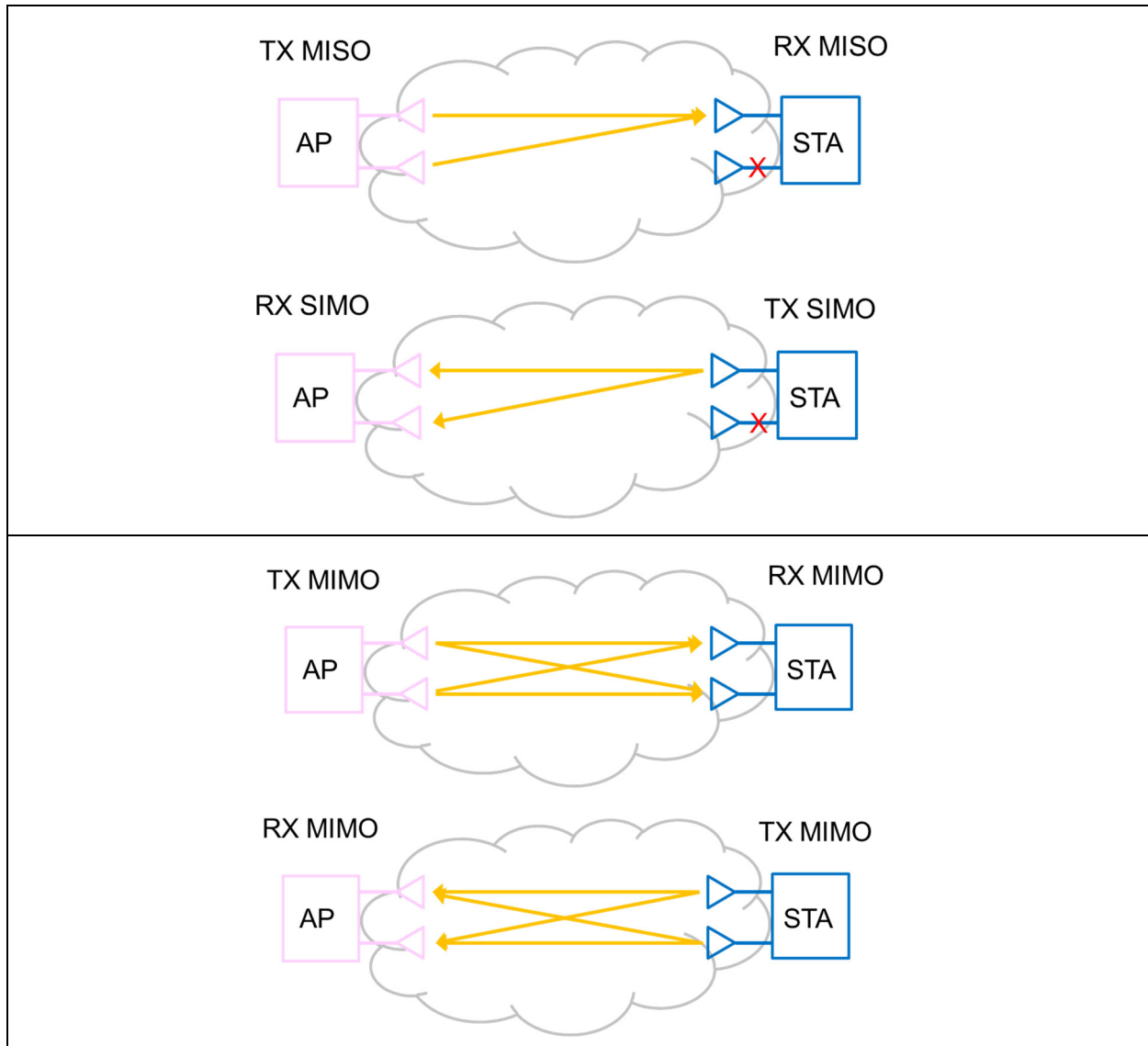
104. Consistent with my Technical Background section (Section V), more broadly, Li also teaches that STA 150 can “operate in multiple operating modes” that enable one or multiple transmitter and receiver circuits, including:

In a SISO operating mode, a single transmitter and a single receiver may be used to communicate information signals over a wireless shared medium 160. In a MISO operating mode, two or more transmitters may transmit information signals over wireless shared media 160, and information signals may be received from wireless shared media 160 by a single receiver of a MIMO system. In a *SIMO operating mode*, *one transmitter* and two or more receivers may be used to communicate information signals over wireless shared media. In a *MIMO operating*

mode, two or more transmitters and two or more receivers may be used to communicate information signals over wireless shared media 160.

Ex-1005 ¶17. These modes are the same modes illustrated in the simplified drawings that I provided in the Technical Background section (Section V) of this report.

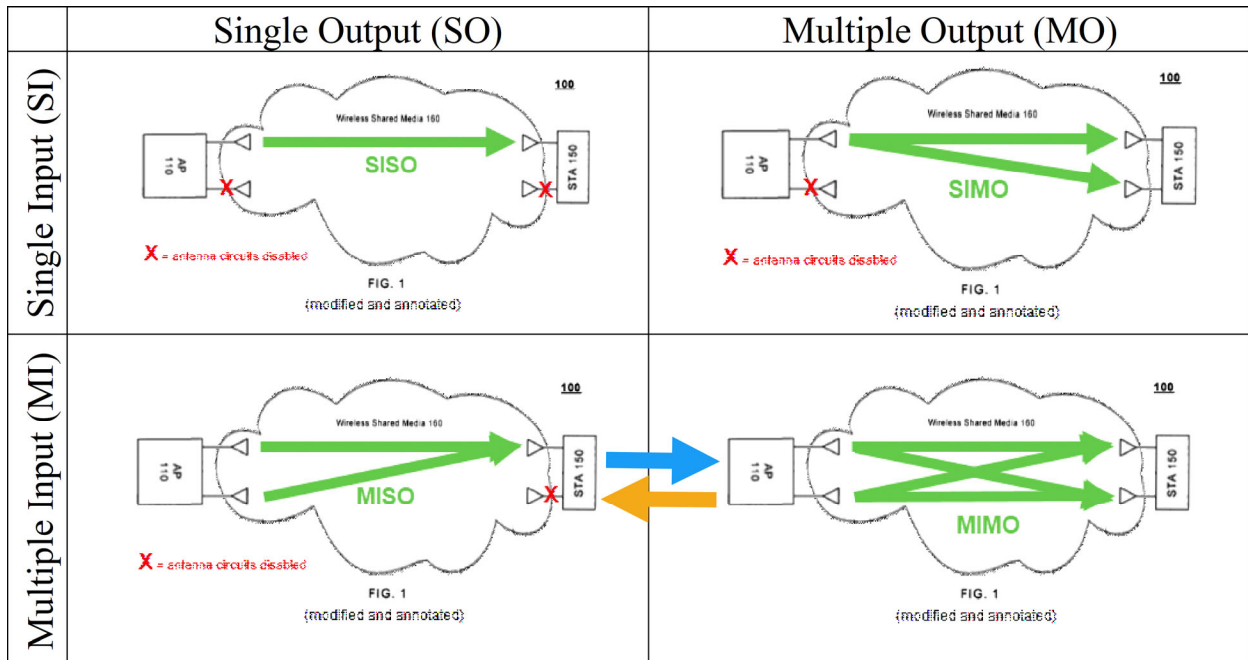




105. Thus, because there are only four possible states for the controller (MAC 210) to “select” from, a POSITA would have recognized from the more general description of paragraphs 17 and 19, that the request (i.e., the control signal) from AP 110 may “enable an operation of desired number of receivers and transmitters” suggests that a first operating mode could also be MIMO, when mobile STA 150 is using both of the first and second antennas to transmit, and a second

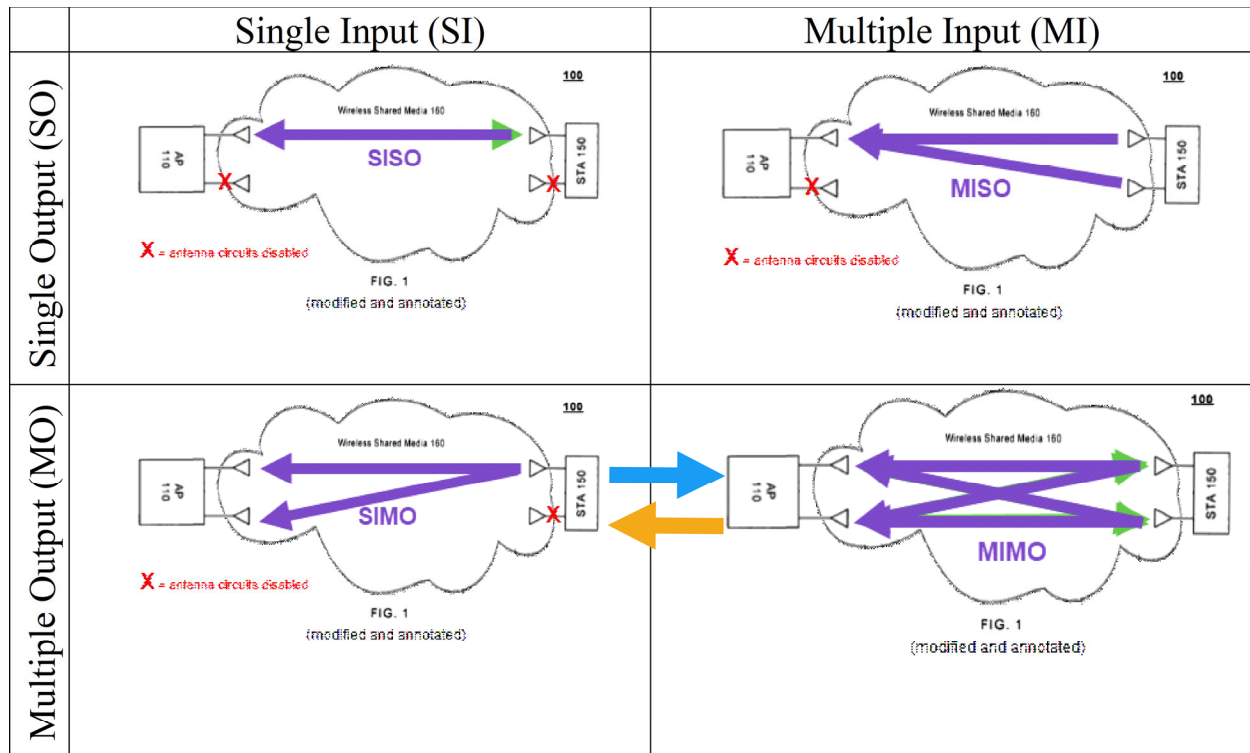
operating mode could be SIMO, when mobile STA 150 is using only one of the first and second antennas to transmit. While this alone teaches or suggests Element 25[d], a POSITA would have had additional reasons to implement a SIMO-MIMO mode switch.

106. For example, consider Li's downlink scenario in which the control signal received by MAC 210 switches the receiver of STA 150 from a MISO to a MIMO mode, STA 150 switches from one receiver to two receivers, Ex-1005 ¶24, which I show in this particular mode transition (MISO to MIMO) in the bottom row with a blue arrow. The orange arrow indicates the opposite switch from MIMO to MISO mode.



107. However, a POSITA would have recognized that in many circumstances, the propagation characteristics of the downlink path are often similar

to the propagation characteristics of the uplink path, and that use of MISO mode between AP 110 (two transmitters) and STA 150 (one receiver) as taught by Li (Ex-1005 ¶24) would have suggested to a POSITA to use (or consider using) SIMO mode as optimal on the uplink between STA 150 (one transmitter) and AP 110 (two receivers) (below, bottom left). Therefore, when Li's MAC receives the control signal to switch receiving STA 150 from MISO to MIMO (to enable a second receiver), a POSITA would have been motivated to apply a similar rationale and consider enabling the second transmit circuit, and use the second enabled antenna at the mobile station STA 150 to transmit data back to the AP 110, which I have shown below as indicated by the blue arrow in the bottom row (and an orange arrow to show the reverse mode switch). As a result, a POSITA implementing the system taught by Li would have configured the control signal to use Li's full capabilities (enabling any number transmitters and receivers (Ex-1005 ¶19)) to have the capability of performing a SIMO-MIMO mode switch as the claim requires.



108. In any event, such a SIMO-MIMO mode switch would also have been obvious in view of Siam’s teachings, as explained below for Element 25[e].

- f. **Element 25[e]: wherein the control signal is based, at least in part, on a power consumption of the first and second circuitry,**

109. As the ’120 Patent explains, the selection of an optimal power mode needs to take into account not only the transmitted power, but also “power consumption of circuitry coupled to a plurality of antennas at the transceiver” such that “power consumed by the circuitry used to process signals for antennas” is also “included in the calculation of the energy-optimized rate.” Ex-1001, 2:51-58.

110. Li-Siam teaches or suggests Element 25[e]. Li teaches that the control signal for switching communication modes is based, at least in part, on a power

consumption of the first and second circuitry used for transmission. For example, Li explains that when a transceiver is not active but waiting to receive incoming signals, “[t]he power consumed by low noise amplifiers and analog-to-digital converters may be multiplied by the number of antennas.” Ex-1005 ¶18. Although Li is referring to the receiver circuit elements in this case, Li’s mobile STA 150 also includes two transmitter circuits (240a-b) when placed in MIMO mode (Ex-1005 ¶17), and a POSITA would have understood that (as with more receiver circuits 250a-b) more enabled transmitter circuits corresponds to larger power consumption, while fewer enabled transmitter circuits corresponds to reduced power consumption “thereby extending the battery life for [mobile] STA120 and STA150.” Ex-1005 ¶19. Li’s teachings are in the context of idling receiver circuits, however, Siam expressly teaches consideration of transmitter circuit power during transmission including when switching from SIMO to MIMO mode.

111. A POSITA would have understood, based on Li’s discussion that multiple antennas and transceivers may consume excessive power because “[t]he power consumed by low noise amplifiers and analog-to-digital converters may be multiplied by the number of antennas” (Ex-1005 ¶18), and that under certain conditions, reducing the number of transmitters would reduce the total power consumption for a given data transfer volume “thereby extending the battery life for [mobile] STA120 and STA150.” Ex-1005 ¶19. And a POSITA would have

understood that Li's discussion of power consumed by circuitry in the receiver chain (e.g., low noise amplifiers and analog-to-digital converters) would also apply to power consumed by circuitry in the transmit chain (e.g., power amplifiers and digital-to-analog converters).

112. Moreover, Siam teaches a protocol that explicitly selects and/or switches between SIMO and MIMO (and SISO and MISO) transmission modes in a MIMO-capable wireless network based on consideration of both transmission power and circuit power. Ex-1006, 875-76. Siam explains that “[w]hile the MIMO mode requires less RF transmission energy than the other three modes, it also incurs the highest circuit energy consumption.” Ex-1006, 875. Thus, “[d]epending on the transmitter-receiver distance,” any of the four modes, SISO, SIMO, MISO, or MIMO, could be “optimal” for reducing total energy consumption. Ex-1006, 875. For example, Siam teaches that “for relatively small distances, circuit power is dominant, and hence a SISO mode is more energy-efficient” but “[a]s the transmitter-receiver separation increases, the tradeoff shifts in favor of multi-antenna modes (SIMO, MISO, or MIMO).” Ex-1006, 876.

113. Siam teaches that the “total power consumption consists of transmission and circuit powers” and provides algorithms for determining under what conditions the system should select and/or switch, for example, between a SIMO or MIMO mode. Ex-1006, 876. In Siam's setup, “each node is equipped with

two antennas.” Ex-1006, 876. However, the number of antennas that are used may vary. Specifically, Siam uses the variable M_t to represent the number of active transmit antennas, which may be either 1 or 2 depending on the antenna mode used. Similarly, the variable M_r represents the number of active receive antennas, which may also be either 1 or 2 depending on the antenna mode used. Siam goes on to describe the values of these two variables depending on the mode where M_t and M_r are the number of transmitter and receiver antennas, respectively. Ex-1006, 876.

114. Siam calculates transmission power (P_t) and circuit power (P_c) separately using two equations. The equation for transmission power is:

$$P_t = (1 + \delta)P_{out}$$

Ex-1006, 877. In this equation, P_{out} is the amount of radiated RF power required to achieve the desired performance given the selected antenna mode (“ P_{out} is the total transmit power at the air interface”), while the factor δ accounts for the fact that power amplifiers are not perfectly efficient and do not translate all of the power that they consume into radiated RF energy (“ δ is a factor that depends on the drain efficiency of the power amplifier and the underlying modulation scheme”). Siam’s equation for circuit power is given by:

$$P_c \approx M_t(P_{DAC} + P_{mix} + P_{filt}) + 2P_{syn} + \\ M_r(P_{LNA} + P_{mix} + P_{IFA} + P_{filr} + P_{ADC})$$

This equation is the total circuit power consumed by both the transmitter and the receiver. At the transmitter, each antenna has associated with it a digital-to-analog

converter (DAC) that consumes P_{DAC} , a mixer that consumes P_{mix} , and a filter that consumes P_{filt} . These are all standard circuit components, but since there are M_t transmit antennas, the circuit power consumed at the transmitter is M_t times the sum of these three values. Similarly, the receiver has standard components that each have an associated power consumption. Specifically, each receive antenna has a low noise amplifier that consumes P_{LNA} , a mixer that consumes P_{mix} , a filter that consumes P_{filr} , and an analog-to-digital converter (ADC) that consumes P_{ADC} . As there is one of these components for each receive antenna, the circuit power consumed at the receiver is M_r times the sum of these four values. Additionally, the transmitter and receiver each have a single frequency synthesizer that creates the frequency onto which the signals are modulated, and the presence of this component does not depend on the number of active antennas. The power consumed by a synthesizer is P_{syn} , and since there is one at the transmitter and one at the receiver, its value is doubled when computing the overall power.

115. As can be appreciated, circuit power, or P_c , increases with each additional transmitter and receiver, M_t and M_r . Siam states that its goal is to design a protocol that minimizes the total energy consumption per bit value (E_{bt}) for a pair of communicating nodes, calculated as:

$$E_{bt} = \frac{P_t + P_c}{R_b}$$

Ex-1006, 877. In this equation, the transmission power P_t and circuit power P_c are

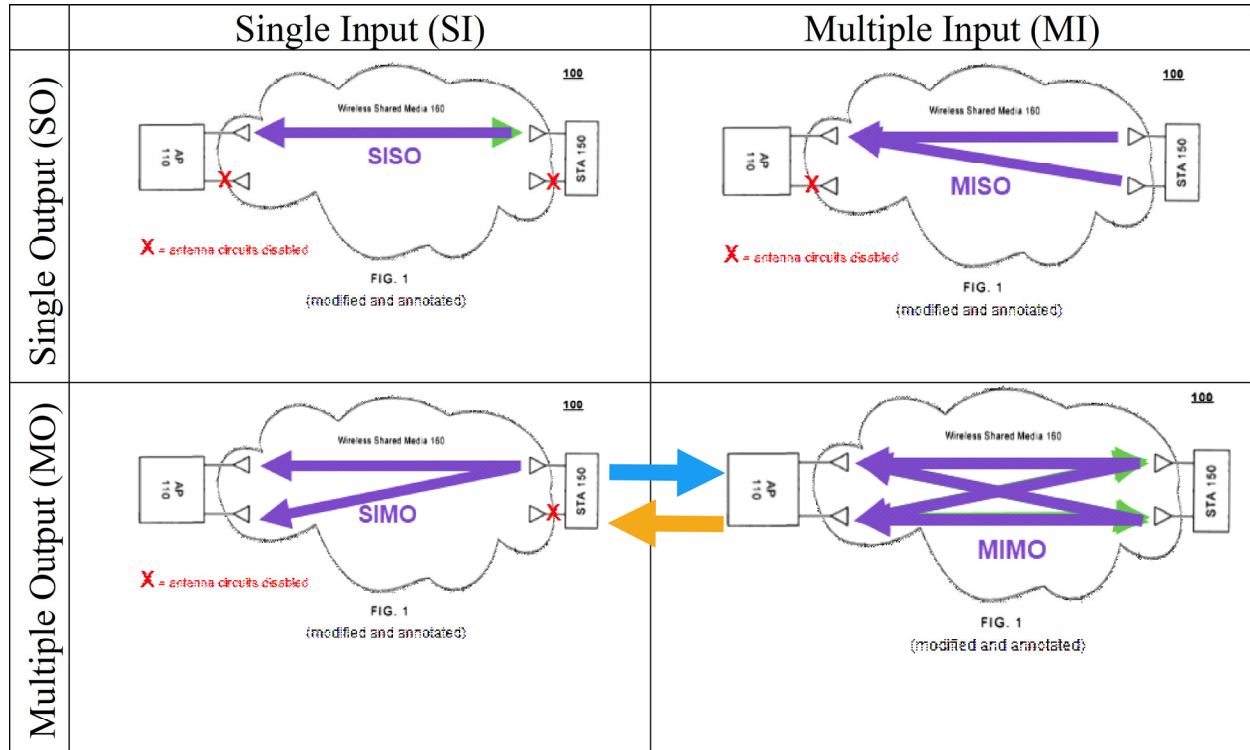
first added together to obtain a total power associated with the transmission. Then this total power is divided by the rate that bits are transmitted (“the bit rate $R_b \approx B$ bits/sec for BPSK modulation”) to determine the total amount of energy required *per bit*⁸. As the foregoing equation shows, the energy per bit depends on the power consumption, P_c , of the circuitry coupled to the antennas at the transmitter and receiver. And, as shown in the equation for P_c , if there are more antennas active at the transmitter, i.e., if M_t is larger, then the value of P_c will be larger.

116. Applying these equations, Siam explains that: “***MIMO may not lead to the minimum total power consumption due to the large value of circuit power,*** which has a varying significance relative to the transmission power in different scenarios. Specifically, at short distances, SISO is more power efficient than MIMO since the circuit power dominates the transmission power [4]. At long distances, MIMO is more power efficient than SISO. ***For intermediate distances, SIMO or MISO may be more power efficient.***” Ex-1006, 377.

117. Thus, as shown below (blue and orange arrows), the combined Li-Siam system would have included a control signal for selecting between a MIMO and SIMO mode, as taught by Li, that depends, at least in part, on the power consumption of the circuitry coupled to the antennas that has a relationship to the distance (short,

⁸ Power is equal to the bit rate times the energy per bit; conversely, the energy per bit is equal to power divide by bit rate.

intermediate, long) between the access point and the mobile station, as taught by Siam.



118. A POSITA would have been motivated to improve Li's mode-switching system by adding Siam's teachings that circuit power consumption should be considered, at least in part, when selecting between a SIMO and MIMO transmission mode, and would have had a reasonable expectation of success in doing so for the same reasons discussed in Section VIII.A.1.

- g. Element 25[f]: wherein the control signal is based, at least in part, on an idle power consumption of the mobile station.**

119. Li-Siam teaches or suggests Element 25[f]. As discussed for Element 25[e], Li teaches that the control signal is based, at least in part, on an idle power

consumption of the entire mobile station. Li explains that “[o]ne problem associated with wireless communication devices using [CSMA/CD] techniques (e.g., 802.11) is power consumption.” Ex-1005 ¶18. As explained above, Li teaches that “a station *in idle mode* waiting for incoming signals may consume approximately 60% of its battery energy.” Ex-1005 ¶18. This is an “inefficient use of energy” that is worsened in MIMO devices because “more than one antenna may be turned on for reception.” Ex-1005 ¶18. Li teaches that “[t]he power consumed by low noise amplifiers and analog-to-digital converters may be multiplied by the number of antennas.” Ex-1005 ¶18. This results in less than 20% of a station’s battery energy being used to communicate actual traffic. Ex-1005 ¶18.

120. As I explained above in Section VIII.A.1, idle power consumption means that the circuits are powered but have nothing to transmit or receive. For example, the ’120 Patent explains that “idle time is a time during which the transceiver may be waiting to send data over the communications channel. The transceiver may, for example, be waiting for a scheduled start time for the transceiver to use the communications channel.” Ex-1001, 2:60-64. On the receiver side, idle power consumption means that the circuits are powered but have nothing to receive.

121. As a proposed solution, Li teaches that AP 110, STA 120, and/or STA 150 may initially be set to operate in a MISO or SISO mode. Ex-1005 ¶19. If desired, AP 110 “may send a request [i.e., control signal] over wireless shared media 160 to

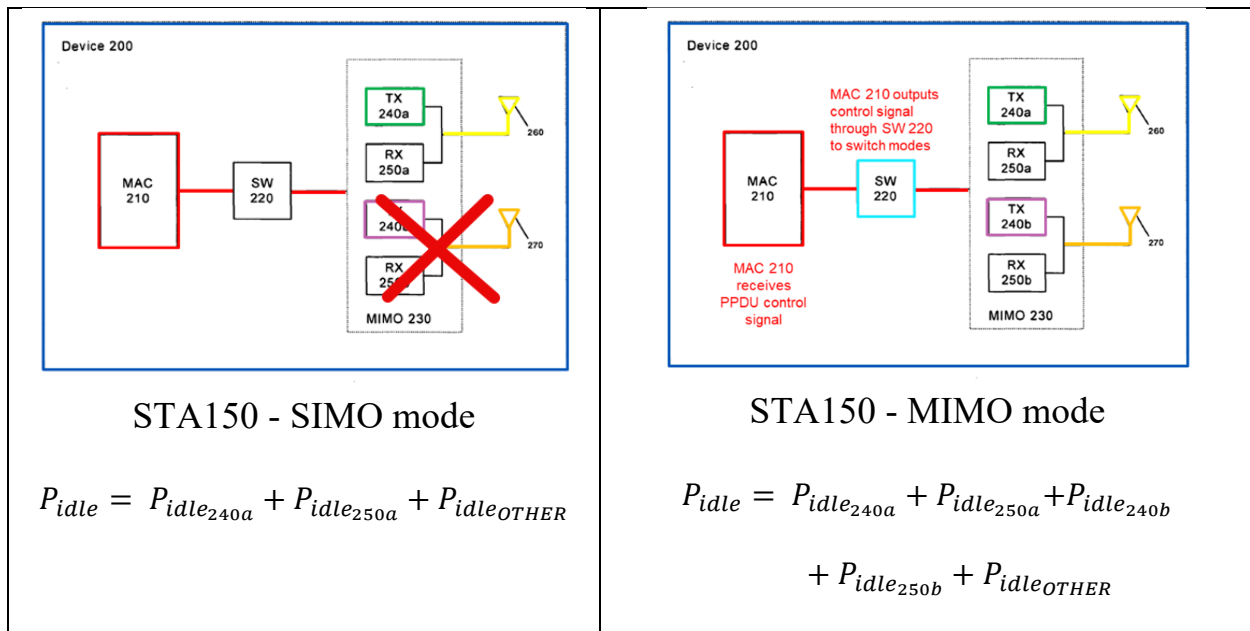
switch STA 120 and STA 150 to a SIMO or MIMO operating mode.” Ex-1005 ¶19.

Stations STA 120 and STA 150 may acknowledge the request/signal and enable operation of the “desired number of receivers and transmitters” of the MIMO system. Ex-1005 ¶19. This allows power consumption to be reduced for STA 120 and STA 150, thereby extending their battery life. Ex-1005 ¶19. Thus, Li’s control signal for switching communication modes is based at least in part on idle power consumption of the mobile station. Since there are no transmissions when the mobile station is in idle mode, the idle power depends on the power drawn by the first and second circuitry while idling. By taking into account this power, Li’s controller is able to select the desired number of transmitters in an effort to achieve Li’s goal of reducing the power consumption of the mobile station.

122. A POSITA would have recognized that the overall idle power consumption related to communications⁹ for the mobile station is the sum of all the transmit and receiver idle power consumption for each activated antenna in MIMO mode plus all of the control circuitry (e.g., MAC 210 and other control circuits). That is, in MIMO mode the idle power consumption is the sum of idle power consumption of idle transmitter circuits 240a and 240b (while waiting to transmit)

⁹ The mobile station has additional sources of power consumption that are not related to communications, such as the screen and application processor, which may still be left on if the user is interacting with an application but not communicating (i.e., in an idle mode). Such additional sources of power consumption are outside the scope of my discussion.

and idle power consumption of idle receiver circuits 250a and 250b (while waiting to receive) plus the power consumption of control processors of the mobile station STA 150. In SIMO mode, where TX 240b is off and assuming RX 250b is also off, they no longer contribute to station idle power consumption. The difference in MIMO and SIMO station idle power is indicated by my corresponding equations below:



where $P_{idle_{TX240a}}$ and $+ P_{idle_{TX240b}}$ are the idle power consumptions of transmitter circuits 240a and 240b, respectively, $P_{idle_{RX250a}}$ and $P_{idle_{RX250b}}$ are the idle power consumptions of receiver circuits 250a and 250b, respectively, and $P_{idle_{OTHER}}$ is the power consumption due to the control processor or processors.

123. Thus, as discussed for Element 25[e], Li teaches that AP 110 may send a control signal to STA 150 to switch between SIMO and MIMO to enable the

“desired number of receivers and transmitters” of the MIMO system. Ex-1005 ¶19.

This allows power consumption to be reduced for STA 150, thereby extending its battery life. Ex-1005 ¶19. And, as also discussed, Siam teaches an algorithm that expressly takes circuit power into account when selecting between a SIMO and MIMO mode. Ex-1006, 877. Thus, a POSITA would have understood and been motivated to configure Li’s control signal for switching communication modes to also be based at least in part on overall circuit power consumption, and more precisely, on circuit power consumed while the mobile station is idle and not receiving or transmitting.

124. A POSITA would have been motivated to combine Li’s teachings with Siam’s teachings and had a reasonable expectation of success in doing so, for the reasons I explain in Section VIII.A.1.

3. Dependent Claims 27 and 28

a. Dependent Claim 27: The mobile station of claim 25, wherein the control signal is based, at least in part, on energy optimized rates for the MIMO mode and the SIMO mode

125. Li-Siam teaches or suggests Claim 27.

126. As explained in Sections VIII.A.2.e-VIII.A.2.g, Siam assumes a fixed rate system and states that its goal is to design a protocol that minimizes the total energy consumption per bit (E_{bt}) for a pair of communicating nodes, calculated as, calculated as:

$$E_{bt} = \frac{P_t + P_c}{R_b}$$

Ex-1006, 877. In this equation, the transmission power P_t and circuit power P_c are first added together to obtain a total power associated with the transmission. Then this total power is divided by the rate that bits are transmitted (“the bit rate $R_b \approx B$ bits/sec for BPSK modulation”) to determine the total amount of energy required *per bit*¹⁰. Siam assumes that the rate R_b is fixed and therefore minimizes the energy per bit by minimizing the power ($P_t + P_c$). A POSITA would have understood that it would have been obvious that a system that assumes a fixed bit rate and selects the modulation scheme that minimizes the power is just the complement of a system that assumes a fixed power and selects the modulation scheme that maximizes the data rate for each mode. This would be clear to a POSITA who would recognize that E_{bt} is the ratio of two numbers – a numerator containing the power divided by a denominator containing the bit rate. The POSITA would recognize that a ratio can be minimized by minimizing its numerator (i.e., minimizing power) while holding its denominator fixed (i.e., maximizing bit rate), or it can be minimized by holding its numerator fixed (i.e., fixing power) while maximizing its denominator (i.e., maximizing the bit rate). Thus, a POSITA would have understood that Siam’s

¹⁰ Power is equal to the bit rate times the energy per bit; conversely, the energy per bit is equal to power divide by bit rate.

algorithm for selecting between a MIMO mode and a SIMO mode would work the same way in either case. In other words, Siam's algorithm would select the mode between SIMO and MIMO that would exhibit the highest bit rate for a given power. Thus, making Li's control signal dependent on energy optimized rates for MIMO and SIMO, as calculated by Siam, would have been equivalent to making the control signal dependent on minimizing the energy per bit. Therefore, Li-Siam also renders Claim 27 obvious.

127. A POSITA would have been motivated to combine Li's teachings with Siam's teachings and had a reasonable expectation of success in doing so, for the reasons I explain in Section VIII.A.1.

b. Dependent Claim 28: The mobile station of claim 25, wherein the control signal is transmitted to the mobile station by a base station.

128. Li-Siam teaches or suggests Claim 28.

129. Li teaches that access point AP 110 communicates signals encoded with control information using wireless shared media 160. Ex-1005 ¶12. In one embodiment, AP 110 acting as a base station "may send a request over wireless shared media 160 to switch" mobile stations "STA 120 and STA 150 to a SIMO or MIMO operating mode, if desired." Ex-1005 ¶19. STA 120 and STA 150 then "acknowledge the request and may enable an operation of the desired number of receivers and transmitters of the MIMO receivers-transmitters system." *Id.*; *see also*

id. ¶25 (“When implemented as part of an AP such as AP 110, node 200 may initiate a request to switch a station ... into a SIMO or MIMO operating mode.”). A POSITA would have understood that in this embodiment the control signal to select a SIMO or MIMO mode is the PPDU message transmitted to the mobile station (STA 120 and STA 150) by a base station (AP 110). Ex-1005 ¶¶24, 27, 30.

B. Ground 2: Claims 25, 27 and 28 Are Obvious Over Li-Siam in View of Cui-2003

1. A POSITA would have been motivated to combine Li-Siam’s teachings and Cui-2003’s teachings and would have had a reasonable expectation of success

130. A POSITA would have been motivated to combine Li-Siam’s teachings and Cui-2003’s teachings (“Li-Siam-Cui-2003”) and would have had a reasonable expectation of success in doing so, because all three describe systems that select an optimal data communication mode in a wireless communication system, from among SISO, MISO, SIMO, and MIMO modes, in order to reduce the total energy consumption of the system. Ex-1005 ¶¶18 (“One problem associated with wireless communication devices ... is power consumption.”), 19 (“AP 110 operating in a MISO or a SISO operating mode may send a request over wireless shared media 160 to switch STA 120 and STA 150 to a SIMO or MIMO operating mode, if desired. ... In this manner, power consumption for STA 120 and STA 150 may be reduced, thereby extending the battery life for STA 120 and STA 150.”); Ex-1006, 875 (“[W]e dynamically adjust the ‘transmission mode’ and the transmission power on a per-

packet basis so as to minimize the total energy consumption.”); Ex-1007, 2805 (“[W]e analyze the best modulation strategy to minimize the total energy consumption required to send a given number of bits.”).

131. As discussed for Ground 1, above, Li’s system performs the mode selection using a MAC (“multiple access control”) controller (MAC 210) that receives a PPDU message (i.e., a network message) and outputs a control signal in response. The control signal causes the system to switch from a first communication mode to a second communication mode within a MIMO-capable system, as explained in Section VIII.A.2.e (applying Li-Siam to claim Element 25[d]). Ex-1005 ¶¶24-25.

132. As further explained above, Siam complements Li by expressly teaching a protocol (called E-BASIC) for switching the *transmit* mode of a MIMO-capable system between using a single transmit antenna (SIMO or SISO) and using multiple transmit antennas (MIMO or MISO) to reduce total energy consumption. Ex-1006, 875. While both Li and Siam switch modes to reduce power consumption, Siam’s protocol expressly takes into consideration both RF transmission power and circuit power consumption. Ex-1006, 875-76. For example, Siam teaches that “[w]hile the MIMO mode requires less RF transmission energy than the other three modes, it also incurs the highest circuit energy consumption.” Ex-1006, 875-876. Furthermore, Siam expressly teaches selecting between SIMO and MIMO in

transmission modes. Ex-1006, 875-76.

133. Cui-2003 further improves the method for selecting the best transmission mode. Cui-2003 teaches methods for selecting “the best modulation strategy to minimize the total energy consumption” in a wireless transceiver network. Ex-1007, 2805. Cui-2003 specifically considers the power consumption of the circuitry coupled to the antennas in active mode, sleep mode, and during transitions back to active mode. Ex-1007, 2806. This “multi-mode operation” allows significant energy to be saved when the sleep mode is used. Ex-1007, 2806.

134. A POSITA would have been motivated to improve Li-Siam’s mode-switching system by adding Cui-2003’s express teaching that power consumption during sleep (i.e., idle) mode should be expressly considered in determining the most efficient modulation strategy. Cui-2003 explains that “when there is a signal to transmit all circuits work in active mode, [and] when there is no signal to transmit they work in sleep mode” Ex-1007, 2806. Thus, a POSITA would have recognized that Cui-2003’s “sleep” mode is the claimed “idle” mode (i.e., circuits powered on but not transmitting). In the combined Li-Siam-Cui-2003 system, Li’s PPDU message (a control signal) received by Li’s MAC 210 for switching communication modes would be based on both Siam’s teaching that both transmission power and circuit power should be considered and Cui-2003’s teaching that power expended in a sleep (i.e., idle) mode should also be considered when

selecting the optimal communication mode. Additionally, it would ensure a more efficient system because the mobile station would be able to use more “of its battery energy for communicating actual traffic.” Ex-1005 ¶18.

135. A POSITA would have additionally been motivated to combine Cui-2003 with the Li-Siam system because one of the authors of Siam (Shuguang Cui) is the first listed author of Cui-2003, demonstrating that they may relate to continued work in a common field of effort and continued related developments in that field. Moreover, Siam expressly cites to a similar publication authored by Shuguang Cui and published in 2005 (Cui-2005 (Ex-1025)) for its discussion of trading off transmission and circuit power consumption. Ex-1006, 875-76, 880 (“[A] distance-dependent tradeoff emerges between transmission and circuit powers.” (citing Cui-2005)). A POSITA would thus have been motivated to look to Cui-2003’s teachings for additional implementation details with the Li-Siam combination and would have been brought directly to Cui-2003 given Siam’s citation to Dr. Cui’s other publications in this field of research and the overlapping author on Siam and Cui-2003.

136. A POSITA would have had a reasonable expectation of success in combining the teachings of Li-Siam and Cui-2003 because they teach compatible systems—namely, electronic devices operating in accordance with IEEE 802.11 standard protocols or other data communications standards for wireless

communication systems. Ex-1005 ¶¶15 (“STA 120 and STA 150 may each include a MIMO system having at least two transceivers and two antennas.”), 18-19, 20 (“Some elements may be implemented using, for example, one or more circuits, components, registers, processors, software subroutines, or any combination thereof.”), 21-23, 24 (“MAC 210 may output a receiver control signal in response to the received PPDU. The receiver control signal may cause MIMO system 230 to switch between a first operating mode and a second operating mode in response to the receiver control signal.”), 25; Ex-1006, 875 (“Our energy model accounts for both transmission and the circuit powers.”), 876 (“[E]ach node is equipped with two antennas.”), 877, 878 (“The networks in this scenario are based on the infrastructure mode, which means that there is a centralized AP that can communicate with all other nodes while all other nodes can only communicate with the AP.”); Ex-1007, 2805-806 (“We consider a communication link connecting two wireless nodes. In order to minimize the total energy consumption, all signal processing blocks at the transmitter and the receiver need to be considered in the optimization model. ... We assume that the transceiver circuitry works on a multimode basis[.]”). Additionally, each of Li, Siam, and Cui-2003 purports to solve the problem of inefficient power consumption in wireless communication networks in similar and predictable ways, namely, by selecting and/or switching to an optimal transmission mode to reduce total power consumption and improve overall system performance. Ex-1005 ¶19;

Ex-1006, Abstract; Ex-1007, 2805 (“[I]n order to find the optimal transmission scheme, the overall energy consumption including both transmission and circuit energy consumption needs to be considered.”). A POSITA would have understood that their teachings could be combined with little to no change in their respective functions.

2. Independent Claim 25

a. Element 25[pre]: A mobile station for use in a communications system comprising:

137. Li-Siam-Cui-2003 teaches or suggests Claim 25’s preamble, to the extent it is limiting, for the same reasons described in Section VIII.A.2.a.

b. Element 25[a]: a first antenna and a second antenna;

138. Li-Siam-Cui-2003 teaches or suggests Element 25[a] for the same reasons described in Section VIII.A.2.b.

c. Element 25[b]: first circuitry coupled to the first antenna and configured to process signals for transmission by the first antenna; second circuitry coupled to the second antenna and configured to process signals for transmission by the second antenna; and

139. Li-Siam-Cui-2003 teaches or suggests Element 25[b] for the same reasons described in Section VIII.A.2.c.

d. Element 25[c]: a controller coupled to the first and second circuitry, wherein the controller is configured to receive a control signal and,

140. Li-Siam-Cui-2003 teaches or suggests Element 25[c] for the same

reasons described in Section VIII.A.2.d.

- e. **Element 25[d]: in accordance with the control signal, to select between a multiple-input multiple-output (MIMO) mode wherein both the first and second antennas transmit data over a communications channel and a single-input multiple-output (SIMO) mode wherein only one of the first and second antennas transmit data over a communications channel,**

141. Li-Siam-Cui-2003 teaches or suggests Element 25[d] for the same reasons described in Section VIII.A.2.e.

- f. **Element 25[e]: wherein the control signal is based, at least in part, on a power consumption of the first and second circuitry,**

142. Li-Siam-Cui-2003 teaches or suggests Element 25[e] for the same reasons described in Section VIII.A.2.f.

- g. **Element 25[f]: wherein the control signal is based, at least in part, on an idle power consumption of the mobile station.**

143. Li-Siam-Cui-2003 teaches or suggests Element 25[f].

144. As I explained above in Section VIII.A.A.1, idle power consumption means that the circuits are powered but have nothing to transmit or receive. For example, the '120 Patent explains that "idle time is a time during which the transceiver may be waiting to send data over the communications channel. The transceiver may, for example, be waiting for a scheduled start time for the transceiver to use the communications channel." Ex-1001, 2:60-64. On the receiver side, idle power consumption means that the circuits are powered but have nothing to receive.

145. Cui-2003 teaches methods for selecting “the best modulation strategy to minimize the total energy consumption” in a wireless transceiver network while meeting data throughput and delay requirements. Ex-1007, 2805. For example, Cui-2003 teaches that “in order to find the optimal transmission scheme, the overall energy consumption including both transmission and circuit energy consumption needs to be considered.” Ex-1007, 2805.

146. Cui-2003’s Figures 1 and 2 depict “signal paths on the transmitter and receiver sides.” Ex-1007, 2806, Figs. 1-2 (having identical circuitry (green) components coupled to an antenna (yellow) as in the ’120 Patent’s Figure 4: digital-to-analog converter (brown), filters (pink), mixer (grey), power amplifier (teal)). Cui-2003 considers the power consumption of the circuitry coupled to the antennas in active mode, sleep mode, and during transitions back to active mode. Ex-1007, 2806. Specifically, Cui-2003 “assume[s] that the transceiver circuitry works on a multimode basis: when there is a signal to transmit all circuits work in active mode, when there is no signal to transmit they work in sleep mode, and when switching from sleep mode to active mode there is a transient mode.” Ex-1007, 2806. This “multi-mode operation” allows significant energy to be saved when the sleep mode is used. Ex-1007, 2806.

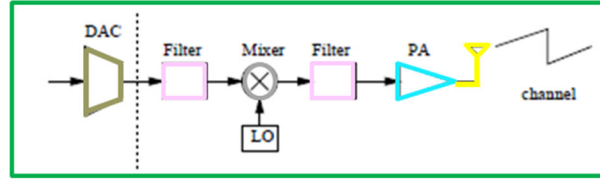


Fig. 1. Transmitter Circuit Blocks (Analog)

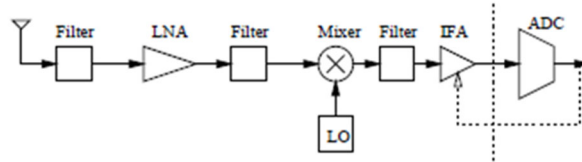


Fig. 2. Receiver Circuit Blocks (Analog)

147. Cui-2003 further teaches that, during a transmission period of time T , the node (i.e., mobile station) may be taking one of three actions: it may be in an active (i.e., transmitting), it may be in a sleep mode (i.e., idle), or it may be in a transient mode, which is a time period between the active and sleep mode needed to allow the frequency synthesizer to settle. Cui-2003 uses the variable T_{on} to represent the amount of time the transmitter spends in the active mode, T_{sp} to represent the time the transmitter is in sleep mode, and T_{tr} to represent the time it is in transient mode. Cui-2003 then teaches that “the total energy consumption E required to send L bits” has three components by its equation (1):

$$\begin{aligned} E &= P_{on}T_{on} + P_{sp}T_{sp} + P_{tr}T_{tr} \\ &= (P_t + P_{c0})T_{on} + P_{sp}T_{sp} + P_{tr}T_{tr}, \end{aligned}$$

“where P_{on} , P_{sp} , and P_{tr} are power consumption values for the active mode, the sleep mode, and the transient mode, respectively.” Ex-1007, 2806. As energy consumption

of a given mode can be found by multiplying the power consumed while in that mode by the time the transmitter is in the mode, it follows that the energy consumption of the active mode is the power consumed while in active mode (P_{on}) multiplied by the time it is in active mode (T_{on}). Similarly, the power consumed while in sleep mode is the power consumed in sleep mode (P_{sp}) multiplied by the time in sleep mode (T_{sp}), while the power consumed in transient mode is the power consumed in transient mode (P_{tr}) multiplied by time in transient mode (T_{tr}). Adding up these three energies gives the total energy. In the second line of the equation, the active power P_{on} is represented by the sum of the transmission signal power P_t and the circuit power consumption P_{c0} . Because Cui-2003 explains that “when there is a signal to transmit all circuits work in active mode, [and] when there is no signal to transmit they work in sleep mode” (Ex-1007, 2806), a POSITA would have understood that “sleep mode” means a mode in which the mobile station is idle and not actively transmitting or receiving data but that mobile stations in sleep mode may nevertheless continue to consume power since they are not completely shut down, as there may still be some minimum current drawn by circuits even when they are not in use. This understanding is consistent with Cui-2003’s equation (1), which includes a power value P_{sp} that represents power consumed while the mobile station

is in sleep mode, and thus, a POSITA would have understood Cui-2003's P_{sp} ¹¹ to be the power consumed by the mobile station when in an idle state. *Id.* A POSITA would thus have understood that Cui-2003 bases modulation selection, in part, on the idle power consumption of a wireless node. This is because idle power P_{sp} is explicitly included in equation (1), and the purpose of the algorithm given by Cui-2003 is to minimize the energy consumption per information bit, $E_a = E/L$. Ex-1007, 2806. Thus, because each idle circuit's power consumption contributes to the mobile station's idle power consumption, Li's control signal for switching communication modes in the combined Li-Siam-Cui-2003 system would be based, at least in part, on an idle power consumption of the mobile station.

148. A POSITA would have been motivated to implement Cui-2003's teaching that power consumption during sleep (i.e., idle) mode should be expressly considered in determining the most efficient modulation strategy with the combined Li-Siam system for the reasons discussed in Section VIII.B.1.

¹¹ Cui-2003 sets $P_{sp}=0$ for some of its analysis, noting that for CMOS technology, leakage current of transistors will be small compared to power expended in active mode. Ex-1007, 2807. But Cui-2003 notes that such analysis "can be easily modified to incorporate $P_{sp}\neq 0$." *Id.*

3. Dependent Claims 27 and 28

- a. Dependent Claim 27: The mobile station of claim 25, wherein the control signal is based, at least in part, on energy optimized rates for the MIMO mode and the SIMO mode.**

149. Li-Siam-Cui-2003 teaches or suggests Claim 27 for the same reasons discussed in Section VIII.A.3.a.

- b. Dependent Claim 28: The mobile station of claim 25, wherein the control signal is transmitted to the mobile station by a base station.**

150. Li-Siam-Cui-2003 teaches or suggests Claim 28 for the same reasons discussed in Section VIII.A.3.b.

C. Ground 3: Claim 26 Is Obvious Over Li-Siam in View of Wu

- 1. A POSITA would have been motivated to combine Li-Siam's teachings and Wu's teachings and would have had a reasonable expectation of success**

151. A POSITA would have been motivated to combine Li-Siam's teachings and Wu's teachings ("Li-Siam-Wu") and would have had a reasonable expectation of success in doing so, because all describe systems that select an optimal data communication mode in a wireless communication system. Ex-1005 ¶¶18 ("One problem associated with wireless communication devices ... is power consumption."), 19 ("Some embodiments may solve this and other problems. ... For example, AP 110 operating in a MISO or a SISO operating mode may send a request over wireless shared media 160 to switch STA 120 and STA 150 to a SIMO or

MIMO operating mode, if desired. ... In this manner, power consumption for STA 120 and STA 150 may be reduced, thereby extending the battery life for STA 120 and STA 150.”); Ex-1006, 875 (“[W]e propose a power-controlled channel access protocol ... where we dynamically adjust the ‘transmission mode’ and the transmission power on a per-packet basis so as to minimize the total energy consumption. By ‘transmission mode’ we mean one of the four possible transmit/receive antenna configurations” SISO, MISO, SIMO, and MIMO); Ex-1009 ¶¶73 (“[T]he base station groups the mobile terminals 16 into one of three groups: a Random User Scheduling (RUS) group, a SIMO group, and a Channel Aware Orthogonal Scheduling (CAOS) group. ... [I]f the velocity of the mobile terminal 16 is greater than the predetermined threshold, the base station 14 may place the mobile terminal 16 in the RUG group.”), 74 (“If the velocity of the mobile terminal 16 is not greater than the predetermined threshold, the base station 14 may then determine the transfer function for each of the sub-carriers within each of the sub-channels assigned to the mobile terminal 16.”), 75 (“The base station 14 then determines whether a channel quality associated with the mobile terminal 16 is poor based on the transfer functions. ... If the channel quality is poor, the base station 14 places the mobile terminal 16 in the SIMO group. ... If the channel quality is not poor, the base station 14 places the mobile station 16 in the CAOS group.”), 76 (base station performs scheduling based on the grouping of the mobile terminals). As

discussed for Ground 1, Li-Siam teaches a controller in a wireless communication system that switches communication modes based on a control signal that depends at least in part on circuit power consumption. Wu similarly evaluates several factors to determine whether the mobile terminals will communicate with the base station through a virtual MIMO link or a SIMO link. Ex-1009 ¶71, Figs. 11A-12. For example, if the mobile terminals are moving very quickly, Wu's base station assumes that the channel is changing too rapidly and randomly schedules the mobile stations to a Random User Scheduling (RUS) group. Ex-1009 ¶73. But if the mobile terminals are moving more slowly, Wu's base station picks one mobile device and then looks for another one such that their channels are most orthogonal and organizes them into a virtual MIMO group to communicate with the base station in a MIMO mode (called a CAOS group). Ex-1009 ¶74. It then proceeds to the next device and finds its most orthogonal partner and sets up another MIMO group with them. Ex-1009 ¶76. But if a certain device has poor channel quality because of high channel correlation with nearby devices, the system instead just sets up a SIMO link between that device and the base station. Ex-1009 ¶75.

152. A POSITA would have been motivated to implement Wu's teachings, which specifically consider correlation in the communications channel when selecting and/or switching between SIMO and MIMO modes, with the combined Li-Siam system because MIMO modes that might otherwise be energy efficient may

not perform well in the presence of high channel correlation. For example, while a MIMO mode may be desirable for its high data throughput, Li notes that MIMO mode can consume a large amount of circuit power. Ex-1005 ¶18; Ex-1006, 875. But if the channel over which the MIMO communication is to take place exhibits high correlation, MIMO will not perform well, and it would be better to select a SIMO mode as Wu suggests. Ex-1009 ¶¶75-76 (selecting a SIMO communication mode when channel quality is low because of high correlation). Thus, consideration of channel correlation would improve the accuracy of the communication mode optimization algorithm. A POSITA would thus have understood that optimizing overall performance of the system would require consideration of both circuit power consumption as well as a correlation in the communications channel.

153. A POSITA would have understood the benefits of implementing these Wu teachings in the combined Li-Siam system because it would increase the mobile station's and/or system's performance in terms of, for example, call quality, data transmission speed, data transmission performance, and battery lifetime because of its ability to accurately optimize transmission modes. Ex-1009 ¶¶71, 73-76.

154. A POSITA would have had a reasonable expectation of success in combining the teachings of Wu with Li-Siam because they teach compatible systems—namely, electronic devices communicating in wireless communication systems using multiple antennas coupled to circuitry. Ex-1005 ¶¶18-19, 20 (“Some

elements may be implemented using, for example, one or more circuits, components, registers, processors, software subroutines, or any combination thereof.”), 21-23, 24 (“MAC 210 may output a receiver control signal in response to the received PPDU. The receiver control signal may cause MIMO system 230 to switch between a first operating mode and a second operating mode in response to the receiver control signal.”), 25; Ex-1006, 875; Ex-1009 ¶¶24 (“[T]he base stations 14 include multiple antennas to provide spatial diversity for communications. The mobile terminals 16 may or may not have multiple antennas.”), 25-27, 28 (“Similarly to the base station 14, the mobile terminal 16 will include a control system 30, a baseband processor 32, transmit circuitry 34, receive circuitry 36, an antenna 38 and user interface circuitry 40.”), 29-30. Although Wu teaches grouping mobile devices into a virtual MIMO group, its teachings would also apply to mobile terminals having two antennas that could be operated in a MIMO configuration. Additionally, Li-Siam and Wu purport to solve the problem of inefficient power consumption in wireless communication networks in similar and predictable ways, namely, by selecting and/or switching to an optimal transmission mode to improve overall system performance. Accordingly, a POSITA would have understood that their teachings could be combined with little to no change in their respective functions. Implementing Wu’s teachings to consider a correlation in the communications channel in selecting and/or switching between a SIMO mode or MIMO mode in the

combined Li-Siam system would have been straightforward, well within the capabilities of a POSITA, and would have been a matter of ordinary engineering and not the product of innovation.

2. Dependent Claim 26: The mobile station of claim 25, wherein the control signal is based, at least in part, on a correlation in the communications channel.

155. Li-Siam renders Claim 25 obvious as set forth in Ground 1 (Section VIII.A.2). Li-Siam-Wu teaches or suggests Claim 26.

156. Wu teaches a communication system including base station 14 and multiple mobile terminals 16 in which the base station “periodically performs an analysis and groups the mobile terminals 16 into two groups: a virtual MIMO group” and a SIMO group (“also [] referred to as a 1x2 diversity group.”) based on the degree of channel correlation. Ex-1009 ¶71. A POSITA would have been motivated to combine Li, Siam, and Wu’s teachings and would have had a reasonable expectation of success in doing so, because each describes systems that select an optimal data communication mode in a wireless communication system. Ex-1005 ¶¶18-19; Ex-1006, 875; Ex-1009 ¶¶73-76. As discussed for Ground 1, Li-Siam teaches a controller in a wireless communication system that switches communication modes based on a control signal that depends at least in part on circuit power consumption. Wu similarly selects between a virtual MIMO mode and a SIMO mode but bases its selection on channel quality. Ex-1009 ¶71, Figs. 11A-

12.

157. In particular, Wu's base station selects one mobile device and then looks for another having the most orthogonal channel (i.e., correlation is low) and organizes them into a virtual MIMO group (a CAOS group) to communicate with the base station in a MIMO mode. Ex-1009 ¶74. It then proceeds to the next device and finds its most orthogonal pair device and sets up another MIMO link between those devices and the base station. Ex-1009 ¶¶7, 76; *see also id.* ¶¶55-57, 63, 65, 67 (describing the CAOS process with Fig. 11A).

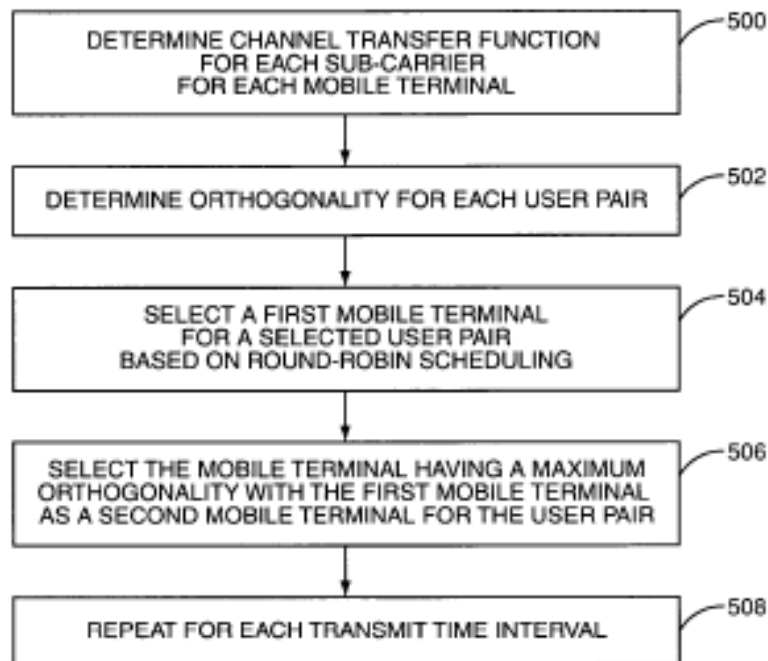


FIG. 11A

158. Wu further teaches that if a certain device has poor channel quality because of high channel correlation, the system instead just sets up a SIMO link for

that device to communicate to the base station individually. Ex-1009 ¶75. Wu explains the well-known relationship that channels that are highly orthogonal to one another have very low correlation. Ex-1009 ¶56. A channel exhibiting high correlation, on the other hand, is a poor quality channel that leads to selection of a SIMO communication mode. Ex-1009 ¶75. The flowchart of Wu's Figure 12 shows this concept:

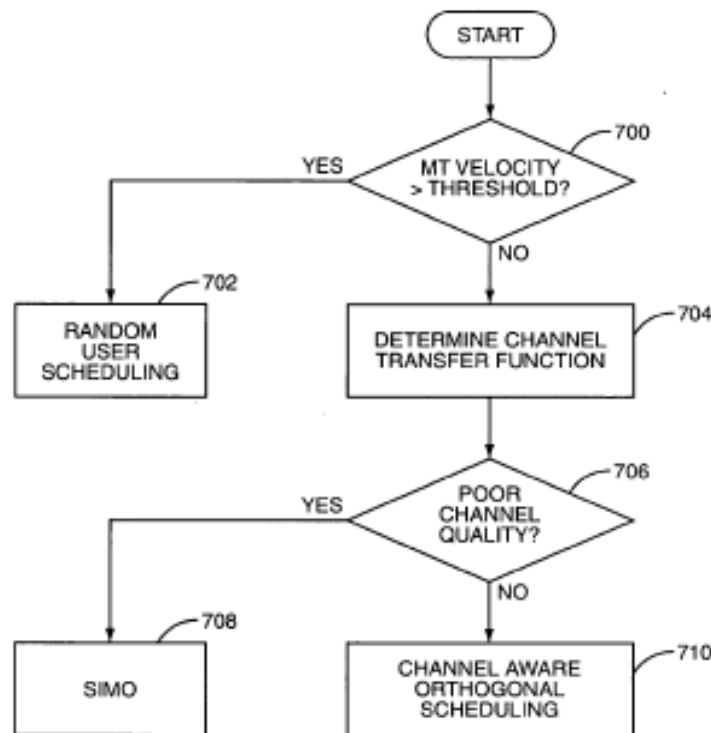


FIG. 12

159. Therefore, Wu teaches that if two devices exhibit low correlation with each other, they have high orthogonality and they are placed in the CAOS group, where they communicate as a virtual MIMO system with the base station. Ex-1009

¶¶75-76. If the channel associated with a device exhibits a high correlation, its channel quality is deemed low, and it communicates by itself with the base station in a SIMO mode. Ex-1009 ¶¶75-76.

160. A POSITA would have been motivated to implement Wu's teachings, which specifically consider correlation in the communications channel when selecting and/or switching between SIMO and MIMO modes, with the combined Li-Siam system, and had a reasonable expectation of success in doing so, for the same reasons described in the previous section.

D. Ground 4: Claim 26 Is Obvious Over Li-Siam-Cui-2003 in View of Wu

1. A POSITA would have been motivated to combine Li-Siam-Cui-2003's teachings and Wu's teachings and would have had a reasonable expectation of success

161. A POSITA would have been motivated to combine Li-Siam-Cui-2003 and Wu and would have had a reasonable expectation of success in doing so for the same reasons described in Sections VIII.B.1 and VIII.C.1.

2. Dependent Claim 26: The mobile station of claim 25, wherein the control signal is based, at least in part, on a correlation in the communications channel.

162. Li-Siam-Cui-2003 renders Claim 25 obvious as set forth in Ground 2 (Section VIII.B.2). Li-Siam-Cui-2003 in view of Wu ("Li-Siam-Cui-2003-Wu") teaches or suggests Claim 26 for the same reasons described in Ground 3 (Section VIII.C.2).

E. Ground 5: Claim 29 Is Obvious Over Li-Siam In View Of Tirola

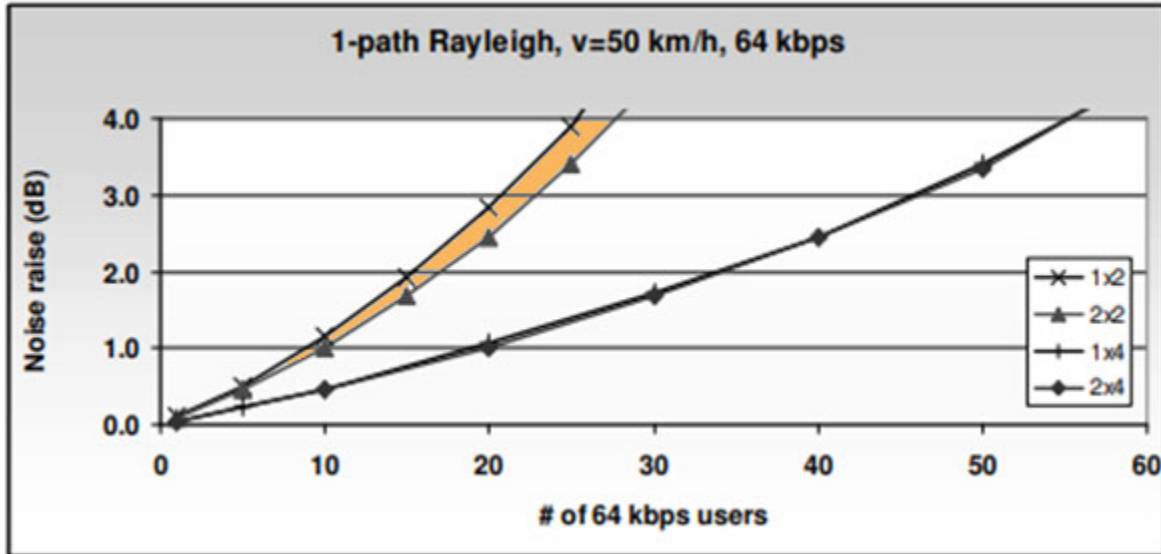
1. A POSITA would have been motivated to combine Li-Siam's teachings and Tirola's teachings and would have had a reasonable expectation of success

163. A POSITA would have been motivated to combine Li-Siam's teachings and Tirola's teachings ("Li-Siam-Tirola") and would have had a reasonable expectation of success in doing so, because all three describe systems that select an optimal data communication mode in a wireless communication system in order to reduce transmission power requirements. Ex-1005 ¶¶18 ("One problem associated with wireless communication devices ... is power consumption."), 19 ("Some embodiments may solve this and other problems. ... For example, AP 110 operating in a MISO or a SISO operating mode may send a request over wireless shared media 160 to switch STA 120 and STA 150 to a SIMO or MIMO operating mode, if desired. ... In this manner, power consumption for STA 120 and STA 150 may be reduced, thereby extending the battery life for STA 120 and STA 150."); Ex-1006, 875 ("[W]e propose a power-controlled channel access protocol ... where we dynamically adjust the 'transmission mode' and the transmission power on a per-packet basis so as to minimize the total energy consumption. By 'transmission mode' we mean one of the four possible transmit/receive antenna configurations" SISO, MISO, SIMO, and MIMO); Ex-1008, 657 ("In this study uplink (UL) performance was studied in the 3rd generation UMTS (Universal Mobile Telecommunications

System) system assuming different SIMO/MIMO (Single/Multiple Input Multiple Output approaches. ... Enhanced uplink performance is crucial for reducing the UE [user equipment] transmission power requirements.”). As discussed in Sections VIII.A.2.e-VIII.A.2.g, the combined Li-Siam system teaches a controller in a wireless communication system that switches between a MIMO and SIMO transmission mode based on a control signal that depends at least in part on circuit power consumption. Tirola similarly considers the relative performance of different antenna configurations that mobile stations may use on the uplink to transmit to a base station, such as 1x2 (SIMO), 1x4 (SIMO), 2x2 (MIMO), and 2x4 (MIMO). Ex-1008, 657, Fig. 1. In addition, Tirola considers the effect of multiple users on the noise level, which can degrade channel performance. For example, Tirola calculates and simulates the effects of the number of users (J) on uplink performance in a code-division-multiple-access (CDMA) system, hence it uses DSSS signaling. Ex-1008, 657-58. While Li discloses one embodiment that may use orthogonal frequency division multiplexing (OFDM) and that is, therefore, relatively immune to increased noise due to multiple users, Li’s “embodiments are not limited in this context.” Ex-1005 ¶53. Li notes that “[t]ypes of WLAN transmitters and/or receivers intended to be within the scope of the embodiments may include, although are not limited to, transmitters and/or receivers for transmitting and/or receiving spread spectrum signals such as, for example, Frequency Hopping Spread Spectrum (FHSS), [and]

Direct Sequence Spread Spectrum (DSSS)[.]” *Id.*; *see also id.* ¶11 (“system 100 may operate in accordance with the IEEE 802.11 wireless local area network (WLAN) series of standard protocols, such as the IEEE 802.11n, 2004 proposed standard,” which used DSSS). A POSITA would have understood that the performance of a system using DSSS (upon which CDMA is also based), would be impacted by multiple users and would benefit from Tirola’s teachings for mitigating degradation caused by multiple users.

164. Specifically, Tirola calculates the increase in noise from the UL (uplink) load factor based on the number of users for various antenna configurations. Ex-1008, 658. Tirola’s simulation of noise rise demonstrates that under certain conditions, noise rise is larger for a 1x2 (SIMO) mode than for a 2x2 (MIMO) mode and the advantage of a MIMO mode increases with increasing number of users. Ex-1008, 659-61, Fig. 4(b). This is shown below by the increasing amount by which the top curve (1x2 SIMO) exceeds the curve immediately below (2x2 MIMO), shown in orange.



165. A POSITA would have been motivated to implement Tirola's teachings, which specifically consider the number of users of the communications system when selecting and/or switching between SIMO and MIMO modes, with the combined Li-Siam system for at least its DSSS embodiments. For example, Li notes that MIMO mode can be inefficient and consume a large amount of circuit power (Ex-1005 ¶18), suggesting that a SIMO mode may be more favorable. Moreover, Siam teaches that MIMO mode "incurs the highest circuit energy consumption." Ex-1006, 875. While this might tend to favor selecting a SIMO mode to save power, Tirola teaches that if there are many users, selecting SIMO mode might increase noise levels sufficiently that RF power (and circuit power) would have to be increased to meet the same data throughput metric. Ex-1008, 659-61, Fig. 4(b). Therefore, a consideration of the number of users would improve the accuracy of the communication mode optimization algorithm. A POSITA would thus have

understood that optimizing overall performance of the system would require consideration of both circuit power consumption as well as the number of users.

A POSITA would have understood that because MIMO modes can be used in all kinds of systems, the idea of switching modes has little to do with whether the system is using, for example, OFDM or CDMA. Nonetheless, because both Li and Tirola teach compatible systems that use DSSS signaling, which CDMA systems are based on, a POSITA would have been motivated to combine their teachings to improve the Li-Siam system in the presence of multiple users.

166. A POSITA would have understood the benefits of implementing these Tirola teachings in the combined Li-Siam system because it would increase the mobile station's and/or system's performance in terms of, for example, call quality, data transmission speed, data transmission performance, and battery lifetime because of its ability to accurately optimize transmission modes. Ex-1006, 879-90; Ex-1008, 658. For example, a POSITA would have understood that a MIMO mode may require more circuit power, but a SIMO mode may result in a noisier channel, thus degrading operation, though that effect may be small for a small number of users. However, a POSITA would have understood that as the noise penalty of a SIMO mode grows with the number of users, it may be advantageous at some point to switch to MIMO operation.

167. A POSITA would have had a reasonable expectation of success in

combining the teachings of Tirola with the combined Li-Siam system because they teach compatible systems—namely, electronic devices communicating in wireless communication systems using multiple antennas coupled to circuitry. Ex-1005 ¶¶15 (“STA 120 and STA 150 may each include a MIMO system having at least two transceivers and two antennas.”), 18-19, 20 (“Some elements may be implemented using, for example, one or more circuits, components, registers, processors, software subroutines, or any combination thereof.”), 21-23, 24 (“MAC 210 may output a receiver control signal in response to the received PPDU. The receiver control signal may cause MIMO system 230 to switch between a first operating mode and a second operating mode in response to the receiver control signal.”), 25; Ex-1006, 875 (“Our energy model accounts for both transmission and the circuit powers.”), 876 (“[E]ach node is equipped with two antennas.”), 877, 878 (“The networks in this scenario are based on the infrastructure mode, which means that there is a centralized AP that can communicate with all other nodes while all other nodes can only communicate with the AP.”); Ex-1008, 657-58 (“Link simulations assumed that the user equipment (UE) has a maximum of two transmit antennas while the base station can employ up to four antennas. ... Circuit-switched 64 kb/s data service specified in 3GPP conformance tests was used in the link simulations.”), Fig. 1. Additionally, each of Li, Siam, and Tirola purports to solve the problem of inefficient power consumption in wireless communication networks in similar and predictable ways,

namely, by selecting and/or switching to an optimal transmission mode to improve overall system performance. Accordingly, a POSITA would have understood that their teachings could be combined with little to no change in their respective functions. Implementing Tirola's teachings to consider the number of users of the system in selecting and/or switching between a SIMO mode or MIMO mode in the combined Li-Siam system would have been straightforward, well within the capabilities of a POSITA, and would have been a matter of ordinary engineering and not the product of innovation.

2. Independent Claim 29

a. Element 29[pre]¹²: A mobile station for use in a communications system comprising:

168. Li-Siam-Tirola teaches or suggests Claim 29's preamble, to the extent it is limiting, for the same reasons described in Section VIII.A.2.a.

b. Element 29[a]: a first antenna and a second antenna;

169. Li-Siam-Tirola teaches or suggests Element 29[a] for the same reasons described in Section VIII.A.2.b.

¹² Claims 25-29 of the '120 Patent are identical except for limitations 25[f] and 29[f]. See Ex-1020 (claim mapping table). My analysis in Ground 1 thus applies equally to limitations 29[pre]-29[e]. Limitation 29[f] is discussed below.

- c. **Element 29[b]: first circuitry coupled to the first antenna and configured to process signals for transmission by the first antenna; second circuitry coupled to the second antenna and configured to process signals for transmission by the second antenna; and**

170. Li-Siam-Tirola teaches or suggests Element 29[b] for the same reasons described in Section VIII.A.2.c.

- d. **Element 29[c]: a controller coupled to the first and second circuitry, wherein the controller is configured to receive a control signal and,**

171. Li-Siam-Tirola teaches or suggests Element 29[c] for the same reasons described in Section VIII.A.2.d.

- e. **Element 29[d]: in accordance with the control signal, to select between a multiple-input multiple-output (MIMO) mode wherein both the first and second antennas transmit data over a communications channel and a single-input multiple-output (SIMO) mode wherein only one of the first and second antennas transmit data over a communications channel,**

172. Li-Siam-Tirola teaches or suggests Element 29[d] for the same reasons described in Section VIII.A.2.e.

- f. **Element 29[e]: wherein the control signal is based, at least in part, on a power consumption of the first and second circuitry,**

173. Li-Siam-Tirola teaches or suggests Element 29[e] for the same reasons described in Section VIII.A.2.f.

- g. **Element 29[f]: wherein the control signal is based, at least in part, on a number of users of the communications system.**

174. Li-Siam-Tiirola teaches or suggests Element 29[f].

175. Tiirola studies uplink (UL) performance in a mobile telecommunications system assuming different SIMO and MIMO transmission approaches from mobile stations having a maximum of two transmit antennas to base stations having up to four antennas. Ex-1008, 657. As I explained in the Technical Background section (Section V), the uplink is the link from the mobile station to the base station. Hence, in the uplink, the mobile station is acting as a transmitter and the base station is acting as a receiver. Figure 1 depicts a “block diagram of the considered SIMO [] and MIMO transmission schemes.” Ex-1008, 657, Fig. 1.

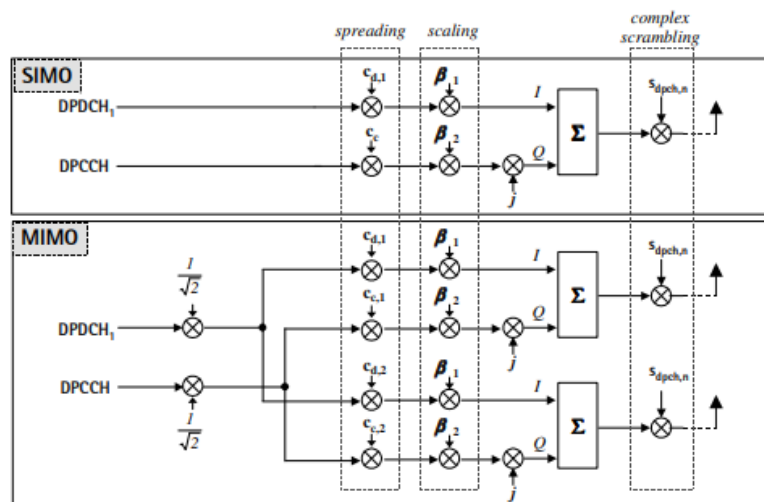


Figure 1. Block diagram of the considered transmission schemes.

176. Tiirola calculates and simulates the effects of the number of users on

uplink performance. Specifically, Tirola teaches that “[w]hen studying the UL performance of different transmission schemes, the UL load factor, denoted as η plays an important role” and is calculated as follows:

$$\eta = (1 + i) \cdot \sum_{j=1}^J \frac{1}{1 + \frac{1}{(E_c / N_0)_j}},$$

“where i is the ratio of other cell to own cell interference, ***J is the number of users*** and E_c/N_0 is the chip energy per total noise power density.” Ex-1008, 658. The UL load factor quantifies the performance impact of having multiple users, i.e., multiple mobile stations, simultaneously transmitting in the wireless network. The performance of the uplink is primarily limited by two kinds of “noise”: thermal noise (denoted N_0 in the above equation), which is independent of the number of users, and interference¹³, which is caused by receiving signals from transmitters other than the intended one. The UL load factor relates the amount of interference to the amount of thermal noise, and it increases when there are more users. In the above equation when “ J ” – which represents the number of users in the cell – increases, the interference increases and so does the load factor due to the summation of more terms in the equation. The load factor also increases when “ i ” – which represents the ratio of other cell to own cell interference – increases, thus interference from

¹³ Noise and interference are sometimes considered separate phenomena, but in the context of Tirola, interference is considered to be a kind of noise.

neighboring cells caused by users in those cells will also increase the UL load factor.

Thus, the UL load factor is a numerical quantity whose value goes up in proportion to the amount of interference within the same cell (via J) and the amount of interference from other cells (via i). Since interference is related directly to the number of users, the load factor is a function of the number of users of the communication system.

177. Tirola translates the UL load factor into another quantity called “noise rise,” which represents the increase in noise at the base station due to the interference, as compared to a base station that only has thermal noise. The noise rise is calculated as follows:

$$\text{Noise_rise} = 10 * \log_{10} \left(\frac{1}{1 - \eta} \right).$$

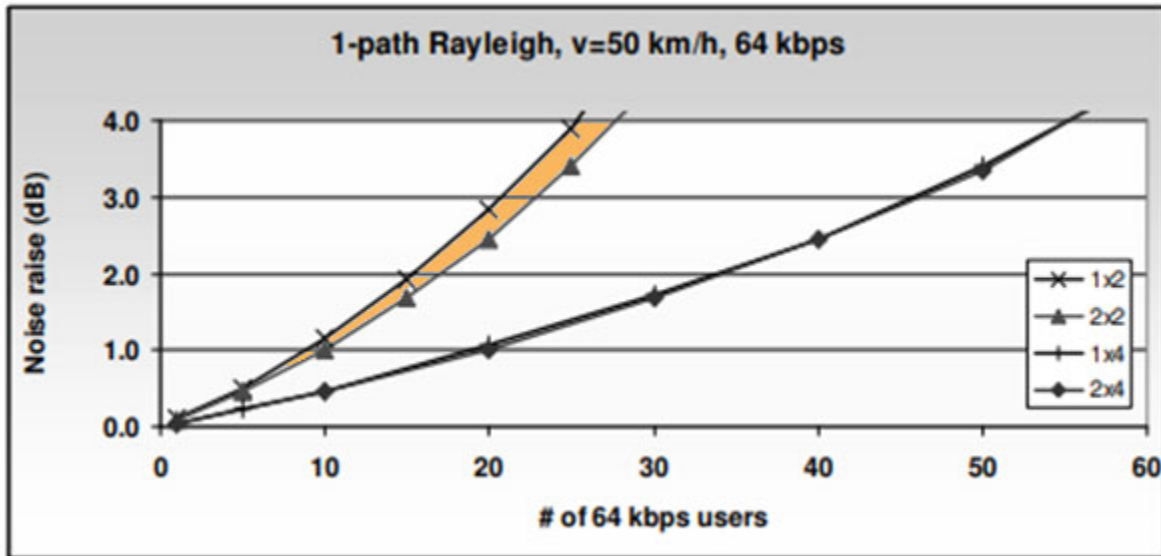
where η is the UL load factor described in the previous paragraph. Ex-1008, 658. The logarithm (“log10”) and multiplication by 10 converts the noise rise to decibels (dB), which is a common logarithmic unit used when dealing with communication systems. Like the UL load factor that it depends upon, noise rise depends on the number of users and its value will increase with increasing numbers of users. Rather than determining noise rise directly using the two equations described above, Tirola uses a simulation and the following equation to calculate noise rise for a given number of users “ j ”:

$$\text{Noise_rise}(j) = \text{Rx} \frac{E_b}{N_0}(j) - \text{Rx} \frac{E_b}{N_0}(1) + \text{Noise_rise}(1),$$

“where $\text{Rx } E_b/N_0(j)$ (dB) is the simulated average $\text{Rx } E_b/N_0$ value (dB) obtained from the multi-user simulation having j simultaneous users and $\text{Noise_rise}(1)$ (dB) corresponds the noise rise caused by a single user.” Ex-1008, 658. Hence, by using this equation and a simulation, the noise rise can be calculated for an arbitrary antenna configuration and an arbitrary number of users.

178. Tirola performed simulations of noise rise for a variety of channel models, vehicular speeds, antenna configurations, and number of users. Tirola’s simulation of noise rise for a particular channel type (“1-path Rayleigh”) and a particular vehicular speed (“ $v=50$ km/h”), depicted in Figure 4(b) shown below, demonstrates that noise rise is larger for a 1x2 (SIMO) mode than for a 2x2 (MIMO) mode and the advantage of a MIMO mode increases with increasing number of users (the number of users is the horizontal axis on this plot). Ex-1008, 659-61, Fig. 4(b). Conversely, the noise penalty of selecting a 1x2 SIMO mode over a 2x2 MIMO mode increases with the number of users. The number of users supported by each of the two modes can be found by fixing the noise rise to a certain target value that depends on the transmission technology used, such as 3 dB, and then comparing the number of users at that noise rise. For instance, at a noise rise of 3 dB, selecting 1x2 SIMO mode supports about 21 users, while selecting a 2x2 MIMO mode supports about 23 users. However, the advantage of a MIMO mode diminishes when the base

station uses four antennas instead of two antennas. Ex-1008, 659-60. This can be seen in the two curves on the right side of Fig. 4(b), which correspond to a 1x4 SIMO mode and a 2x4 MIMO mode. The two curves are virtually on top of one another, which implies that the noise penalties for these two modes are the same.

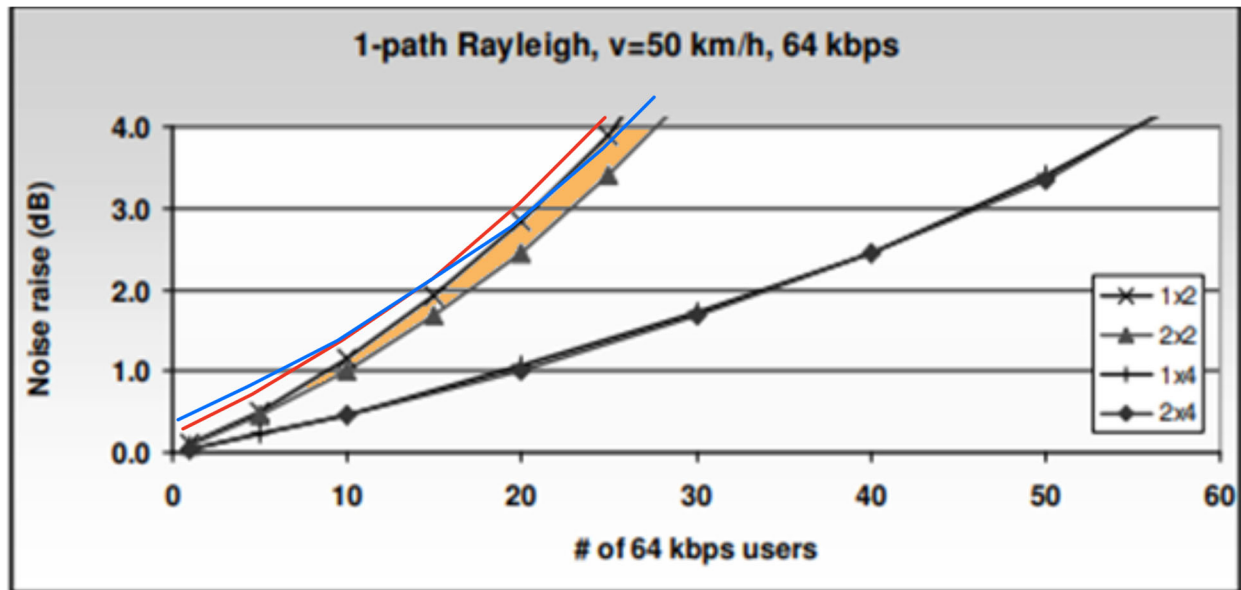


179. A POSITA would have understood based on Tirola's teachings that channel noise considerations might favor, for example, a MIMO mode over a SIMO mode based on the noise rise in the presence of a large number of users. For instance, as I described in the last paragraph, for the conditions simulated in Fig. 2(a), it would generally be preferable to pick the 2-by-2 MIMO mode over the 1-by-2 SIMO mode because the 2-by-2 MIMO mode's noise rise curve is below that of the 1-by-2 SIMO mode. Moreover, the gap between these two curves widens as the number of users increases. The curves shown by Tirola relate to the amount of additional noise caused by the interference caused by the plurality of users in the system, and how

that additional noise differs depending on the mode used. The noise rise translates directly to an additional amount of power that must be transmitted by the mobile station to overcome the interference. However, a POSITA would understand that the total power consumed by the mobile station is not just the transmitted power, but also the circuit power. Li and Siam, on the other hand, teach that MIMO mode consumes more circuit power than SIMO mode. Ex-1005 ¶18; Ex-1006, 875. Thus, when accounting for total power, a POSITA would need to consider not only the noise rise, which determines the amount of transmitted power, but also needs to consider the circuit power of the SIMO or MIMO mode used. A POSITA, therefore, would have understood that if the additional transmit power of Figure 4(b) were to also account for the circuit power, then both curves would need to shift upwards to display total power. However, the amount that the MIMO curve would need to shift upwards would be understood by a POSITA to be higher than the amount that the SIMO curve would need to shift because the MIMO system's circuits consume more power than the SIMO system's. Once these curves are shifted, there could be a crossover point such that consideration of both the power consumption and the number of users of the system would lead the system to choose a SIMO mode over a MIMO mode.

180. This is illustrated in the modified figure shown below. Here, the curve for 1x2 SIMO has been redrawn in red while the curve for 2x2 MIMO has been

redrawn in blue. However, the two curves have shifted upwards to account for circuit power. The amount of the shift for the 2x2 MIMO mode is higher than the shift for the 1x2 SIMO mode due to the fact that MIMO mode consumes more circuit power.



Consequently, the two curves cross—in this example, the cross is at 2 dB noise rise, which corresponds to approximately 14 users. This would imply that if circuit power is taken into account, there would be some crossover point, i.e., number of users, below which the SIMO system would outperform the MIMO system.

181. This understanding is consistent with the teachings of the '120 Patent. *See, e.g.,* Ex-1001, 3:28-4:38 (stating that “[a]ny of a variety of power models may be used to calculate the amount of power consumed by user i during transmission in the MIMO mode” and considering noise power in those calculations), 4:62-5:7 (“A crossover point for when SIMO consumes less power than MIMO, or vice versa, may be considered a function of any of a variety of variables including, but not

limited to, the power consumed by circuitry processing signals for the receive antennas, a number of receive antennas, and channel correlations.”). Thus, in the combined Li-Siam-Tiirola system, Li’s control signal is based, at least in part, on a number of users of the communications system.

182. A POSITA would have been motivated to implement Tiirola’s teachings, which specifically consider the number of users of the communications system when selecting and/or switching between SIMO and MIMO modes, with the combined Li-Siam system, for the reasons discussed in Section VIII.E.1.

IX. CONCLUSION

183. For the reasons set forth above, I believe that Claims 25-29 of the ’120 Patent are unpatentable in view of the prior art.

184. In signing this declaration, I recognize that it will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place in the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

185. I reserve the right to supplement my opinions in the future to respond to any arguments that the Patent Owner raises and to take into account new information as it becomes available to me.

186. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Respectfully Submitted,

Matthew C. Valenti

Date: June 12, 2024