

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Samsung Electronics America, Inc.
Samsung Electronics Co., Ltd.
Petitioners

v.

Cobblestone Wireless LLC
Patent Owner

Case IPR2024-00319
Patent 8,891,347

**DECLARATION OF KEVIN C. ALMEROOTH, PH.D. IN SUPPORT OF
PETITION FOR INTER PARTES REVIEW OF
UNITED STATES PATENT NO. 8,891,347**

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I. INTRODUCTION

1. I have been retained by Samsung Electronics America, Inc. and Samsung Electronics Co., Ltd. (“Petitioners”) as an independent expert consultant in this proceeding before the United States Patent and Trademark Office (“PTO”) against Cobblestone Wireless, LLC (“Patent Owner”) regarding U.S. Patent No. 8,891,347 (“the ’347 Patent”) (Ex. 1001).¹ I have been asked to submit this Declaration on behalf of Petitioners.

2. I have been asked to consider whether certain references disclose or render obvious the features recited in claims 1-4, 6-12, 14-17, and 19-23 (collectively, the “Challenged Claims”) of the ’347 Patent. My opinions are set forth below. Based on my experience and expertise, it is my opinion that the prior art renders obvious all limitations of the Challenged Claims, as I discuss in detail below.

3. I am being compensated at a rate of \$850 per hour for my work in this proceeding. My compensation is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other interest in this proceeding.

¹ Where appropriate, I refer to exhibits that I understand are to be attached to the petition for *Inter Partes* Review of the ’347 patent.

4. All of my opinions stated in this Declaration are based on my own personal knowledge and professional judgment. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth in this Declaration. My opinions in Sections V through VIII are substantively identical as those of Mr. James Proctor in his declaration filed with the Petition in *T-Mobile USA, Inc. v. Cobblestone LLC*, IPR2023-00136 (“Mr. Proctor’s Declaration”). That Petition challenges the same claims of the ’347 Patent, though only presents one ground of challenge based on Sesia. As I explain below, I agree with Mr. Proctor the Challenged Claims are obvious in view of Sesia. In this Declaration, I further opine that the Challenged Claims are also obvious in view of Forenza.

II. BACKGROUND AND QUALIFICATIONS

5. I am currently a Professor Emeritus in the Department of Computer Science at the University of California, Santa Barbara (UCSB). While at UCSB, I held faculty appointments and was a founding member of the Computer Engineering (CE) Program, Media Arts and Technology (MAT) Program, and the Technology Management Program (TMP). I also served as the Associate Director of the Center for Information Technology and Society (CITS) from 1999 to 2012. I have been a faculty member at UCSB since July 1997. I hold three degrees from the Georgia Institute of Technology: (1) a Bachelor of Science degree in Information and Computer Science (with minors in Economics, Technical Communication, and American Literature)

earned in June 1992; (2) a Master of Science degree in Computer Science (with specialization in Networking and Systems) earned in June 1994; and (3) a Doctor of Philosophy (Ph.D.) degree in Computer Science (Dissertation Title: Networking and System Support for the Efficient, Scalable Delivery of Services in Interactive Multimedia System, minor in Telecommunications Public Policy) earned in June 1997. During my education, I took a wide variety of courses as demonstrated by my minor. My undergraduate degree also included a number of courses more typical of a degree in electrical engineering including digital logic, signal processing, and telecommunications theory.

6. One of the major concentrations of my research over the past 30+ years has been the delivery of multimedia content and data between computing devices, including through various network architectures. In my research, I have studied large-scale content delivery systems, and the use of servers located in a variety of geographic locations to provide scalable delivery to hundreds or thousands of users simultaneously. I have also studied smaller-scale content delivery systems in which content is exchanged between individual computers and portable devices. My work has emphasized the exchange of content more efficiently across computer networks, including the scalable delivery of content to many users, mobile computing, satellite networking, delivering content to mobile devices, and network support for data delivery in wireless networks.

7. In 1992, the initial focus of my research was on the provision of interactive functions (e.g., VCR-style functions like pause, rewind, and fast-forward) for near video-on-demand systems in cable systems; in particular, how to aggregate requests for movies at a cable head-end and then how to satisfy a multitude of requests using one audio/video stream broadcast to multiple receivers simultaneously. This research has continually evolved and resulted in the development of techniques to scalably deliver on-demand content, including audio, video, web documents, and other types of data, through the Internet and over other types of networks, including over cable systems, broadband telephone lines, and satellite links.

8. An important component of my research has been investigating the challenges of communicating multimedia content, including video, between computers and across networks including the Internet. Although the early Internet was used mostly for text-based, non-real time applications, the interest in sharing multimedia content, such as video, quickly developed. Multimedia-based applications ranged from downloading content to a device to streaming multimedia content to be instantly used. One of the challenges was that multimedia content is typically larger than text-only content, but there are also opportunities to use different delivery techniques since multimedia content is more resilient to errors. I have worked on a variety of research problems and used a number of systems that were developed to deliver multimedia content to users. One content-delivery method I have researched is the one-to-many

communication facility called “multicast,” first deployed as the Multicast Backbone, a virtual overlay network supporting one-to-many communication. Multicast is one technique that can be used on the Internet to provide streaming media support for complex applications like video-on-demand, distance learning, distributed collaboration, distributed games, and large-scale wireless communication. The delivery of media through multicast often involves using Internet infrastructure, devices and protocols, including protocols for routing and TCP/IP.

9. Starting in 1997, I worked on a project to integrate the streaming media capabilities of the Internet together with the interactivity of the web. I developed a project called the Interactive Multimedia Jukebox (IMJ). Users would visit a web page and select content to view. The content would then be scheduled on one of a number of channels, including delivery to students in Georgia Tech dorms delivered via the campus cable plant. The content of each channel was delivered using multicast communication. In the IMJ, the number of channels varied depending on the capabilities of the server including the available bandwidth of its connection to the Internet. If one of the channels was idle, the requesting user would be able to watch their selection immediately. If all channels were streaming previously selected content, the user’s selection would be queued on the channel with the shortest wait time. In the meantime, the user would see what content was currently playing on other channels,

and because of the use of multicast, would be able to join one of the existing channels and watch the content at the point it was currently being transmitted.

10. The IMJ service combined the interactivity of the web with the streaming capabilities of the Internet to create a jukebox-like service. It supported true Video-on-Demand when capacity allowed, but scaled to any number of users based on queuing requested programs. As part of the project, we obtained permission from Turner Broadcasting to transmit cartoons and other short-subject content. We also connected the IMJ into the Georgia Tech campus cable television network so that students in their dorms could use the web to request content and then view that content on one of the campus's public access channels.

11. More recently, I have also studied issues concerning how users choose content, especially when considering the price of that content. My research has examined how dynamic content pricing can be used to control system load. By raising prices when systems start to become overloaded (i.e., when all available resources are fully utilized) and reducing prices when system capacity is readily available, users' capacity to pay as well as their willingness can be used as factors in stabilizing the response time of a system. This capability is particularly useful in systems where content is downloaded or streamed on-demand to users.

12. As a parallel research theme, starting in 1997, I began researching issues related to wireless devices and sensors. In particular, I was interested in showing

how to provide greater communication capability to “lightweight devices,” i.e., small form-factor, resource-constrained (e.g., CPU, memory, networking, and power) devices. Starting in 1998, I published several papers on my work to develop a flexible, lightweight, battery-aware network protocol stack. The lightweight protocols we envisioned were similar in nature to protocols like Bluetooth, Universal Plug and Play (UpnP) and Digital Living Network Alliance (DLNA).

13. From this initial work, I have made wireless networking—including ad hoc, mesh networks and wireless devices—one of the major themes of my research. My work in wireless networks spans the protocol stack from applications through to the encoding and exchange of data at the data link and physical layers. At the application layer, even before the large-scale “app stores” were available, my research looked at building, installing, and using apps for a variety of purposes, from network monitoring to support for traditional computer-based applications (e.g., content retrieval) to new applications enabled by ubiquitous, mobile devices. For example, my research has looked at developing applications for virally exchanging and tracking “coupons” through “opportunistic contact” among mobile wireless devices (i.e., communication among devices moving into communication range with each other). In many of the courses I have taught there is a project component. Through these projects I have supervised numerous efforts to develop new “apps” for download and use across a variety of mobile platforms.

14. Toward the middle of the protocol stack, my research has also looked to build wireless infrastructure support to enable communication among a set of mobile devices unaided by any other kind of network infrastructure. These kinds of networks are useful either in challenged network environments (e.g., when a natural disaster has destroyed existing infrastructure) or when suitable support for network communication never existed. The deployment of such networks (or even the use of traditional network support) are critical to support services like disaster relief, catastrophic event coordination, and emergency services deployment.

15. Yet another theme is monitoring wireless networks, in particular different variants of IEEE 802.11 compliant networks, to (1) understand the operation of the various protocols used in real-world deployments, (2) use these measurements to characterize use of the networks and identify protocol limitations and weaknesses, and (3) propose and evaluate solutions to these problems. I have successfully used monitoring techniques to study wireless data link layer protocol operation and to improve performance by enhancing the operation of such protocols. For wireless protocols, this research includes functions like network acquisition and channel bonding.

16. One theme in my wireless network research has been cross-layer solutions and innovations. As mentioned above, with greater wireless device use and network support, we envisioned new application paradigms and services, for example,

when mobile devices come into contact with each other. Instead of relying on existing infrastructure to relay communication, the devices are able to discover each other and communicate directly. Other examples include discovering and using location information to enhance users' experiences. Network support and novel applications span use a variety of network architectures supporting users on foot, in vehicles, and across varying terrains and environments. Finally, we studied how communication efficiency can be supported through intelligent handoffs as well as location and movement prediction.

17. Protecting networks, including their operation and content, has been an underlying theme of my research almost since the beginning of my research career. Starting in 2000, I have been involved in several projects that specifically address security, network protection, and firewalls. After significant background work, a team on which I was a member successfully submitted a \$4.3M grant proposal to the Army Research Office (ARO) at the Department of Defense to propose and develop a high-speed intrusion detection system. Key aspects of the system included associating streams of packets and analyzing them for viruses and other malware. Once the grant was awarded, we spent several years developing and meeting the milestones of the project. A number of my students worked on related projects and published papers on topics ranging from intrusion detection to developing advanced techniques to be incorporated into firewalls. I have also used firewalls, including their associated

malware detection features, in developing techniques for the classroom to ensure that students are not distracted by online content.

18. My recent work ties some of the various threads of my past research together. I have investigated content delivery in online social networks and proposed reputation management systems in large-scale social networks and marketplaces. On the content delivery side, I have looked at issues of caching and cache placement, especially when content being shared and the cache has geographical relevance. We were able to show that effective caching strategies can greatly improve performance and reduce deployment costs. Our work on reputation systems showed that reputations have economic value, and as such, creates a motivation to manipulate reputations. In response, we developed a variety of solutions to protect the integrity of reputations in online social networks. The techniques we developed for content delivery and reputation management were particularly relevant in peer-to-peer communication and recommendations for downloadable “apps.”

19. As an important component of my research program, I have been involved in the development of academic research into available technology in the market place. One aspect of this work is my involvement in the Internet Engineering Task Force (IETF). The IETF is a large and open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. I have been involved

in various IETF groups including many content delivery-related working groups like the Audio Video Transport (AVT) group, the MBone Deployment (MBONED) group, Source Specific Multicast (SSM) group, the Inter-Domain Multicast Routing (IDMR) group, the Reliable Multicast Transport (RMT) group, the Protocol Independent Multicast (PIM) group, etc. I have also served as a member of the Multicast Directorate (MADDOGS), which oversaw the standardization of all things related to multicast in the IETF. Finally, I was the Chair of the Internet2 Multicast Working Group for seven years.

20. My involvement in the research community extends to leadership positions for several academic journals and conferences. I am the co-chair of the Steering Committee for the ACM Network and System Support for Digital Audio and Video (NOSSDAV) workshop and on the Steering Committees for the International Conference on Network Protocols (ICNP), ACM Sigcomm Workshop on Challenged Networks (CHANTS), and IEEE Global Internet (GI) Symposium. I have served or am serving on the Editorial Boards of IEEE/ACM Transactions on Networking, IEEE Transactions on Mobile Computing, IEEE Network, ACM Computers in Entertainment, AACE Journal of Interactive Learning Research (JILR), and ACM Computer Communications Review. I have co-chaired a number of conferences and workshops including the IEEE International Conference on Network Protocols (ICNP), IEEE Conference on Sensor, Mesh and Ad Hoc Communications and Networks

(SECON), International Conference on Communication Systems and Networks (COMSNETS), IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS), the International Workshop On Wireless Network Measurement (WiNMee), ACM Sigcomm Workshop on Challenged Networks (CHANTS), the Network Group Communication (NGC) workshop, and the Global Internet Symposium, and I have served on the program committees for numerous conferences.

21. Furthermore, in the courses I taught at UCSB, a significant portion of my curriculum covered aspects of the Internet and network communication including the physical and data link layers of the Open System Interconnect (OSI) protocol stack, and standardized protocols for communicating across a variety of physical media such as cable systems, telephone lines, wireless, and high-speed Local Area Networks (LANs). The courses I have taught also cover most major topics in Internet communication, including data communication, multimedia encoding, and mobile application design. My research and courses have covered a range of physical infrastructures for delivering content over networks, including cable, Integrated Services Digital Network (ISDN), Ethernet, Asynchronous Transfer Mode (ATM), fiber, and Digital Subscriber Line (DSL). For a complete list of courses I have taught, see my curriculum vitae (CV).

22. In addition, I co-founded a technology company called Santa Barbara Labs that was working under a sub-contract from the U.S. Air Force to develop very accurate emulation systems for the military's next generation internetwork. Santa Barbara Labs' focus was in developing an emulation platform to test the performance characteristics of the network architecture in the variety of environments in which it was expected to operate, and, in particular, for network services including Ipv6, multicast, Quality of Service (QoS), satellite-based communication, and security. Applications for this emulation program included communication of a variety of multimedia-based services, including video conferencing and video-on-demand. In addition to having co-founded a technology company myself, I have worked for, consulted with, and collaborated with companies for nearly 30 years. These companies range from well-established companies to start-ups and include IBM, Hitachi Telecom, Turner Broadcasting System (TBS), Bell South, Digital Fountain, RealNetworks, Intel Research, Cisco Systems, and Lockheed Martin.

23. Through my graduate education, leadership with CITS, involvement in TMP, role in the development of the Internet2 infrastructure, and consulting with ISPs, I have gained a strong understanding in the role of the Internet in our society and the challenges of deploying large-scale production networking infrastructure. CITS, since its inception, has looked at the role of the Internet in society, including how the evolution of technology have created communication opportunities and challenges,

including, for example through disruptive technologies like P2P. TMP looks to focus on non-purely technical issues, including, for example, state-of-the-art business methods, strategies for successful technology commercialization, new venture creation, and best practices for fostering innovation. Through my industry collaborations and Internet2 work, I have developed significant experience in the challenges of deploying, monitoring, managing, and scaling communication infrastructure to support evolving Internet services like streaming media, conferencing, content exchange, social networking, and e-commerce.

24. I am a Member of the Association of Computing Machinery (ACM) and a Fellow of the Institute of Electrical and Electronics Engineers (IEEE). Additional details about my employment history, fields of expertise, courses taught, and publications are further included in my CV (Ex. 1016). Based on my professional experience, I believe I am qualified to testify as an expert on matters related to the patent at issue.

III. MATERIALS REVIEWED

25. The opinions contained in this Declaration are based on the documents I reviewed, my professional judgment, as well as my education, experience, and knowledge. They are also based on Mr. Proctor's Declaration, whose opinions I agree with. In forming my opinions expressed in this Declaration, I also reviewed the following materials and information:

Exhibit No.	Description
1001	U.S. Patent No. 8,891,347 to Yin
1002	Prosecution History of the '347 Patent
1003	Stefania Sesia, et al., "LTE: The UMTS Long Term Evolution from Theory to Practice
1004	Declaration of Dr. Hall-Ellis regarding the publication date of Sesia
1006	Patent Owner's Infringement Contentions against AT&T in <i>Cobblestone Wireless, LLC v. AT&T Inc. et al</i> , No. 2:22-cv-00474 (E.D. Tex.) filed December 15, 2022
1007	3GPP TSG RAN WG1 Meeting #60, R1-101217, February 22-23, 2010, San Francisco, USA, available at https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_60/Docs
1008	3GPP TSG RAN WG1 Meeting #60, R1-100926, February 22-26, 2010, San Francisco, USA, available at https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_60/Docs
1009	Patent Owner's Infringement Contentions against T-Mobile in <i>Cobblestone Wireless, LLC v. T-Mobile USA, et al.</i> No. 2:22-cv-00477 (E.D. Tex.) filed December 16, 2022
1010	Patent Owner's Infringement Contentions against Verizon in <i>Cobblestone Wireless, LLC v. Verizon Communications Inc., et al.</i> , No. 2:22-cv-00478 (E.D. Tex.) filed December 16, 2022
1013	Wiley Online Library listing for Sesia as of November. 22, 2023 (https://onlinelibrary.wiley.com/doi/book/10.1002/9780470978504?SeriesKey=10.1002/9780470742891)
1014	U.S. Patent No. 8,654,815

Exhibit No.	Description
1015	Patent Owner's Infringement Contentions against Samsung in <i>Cobblestone Wireless, LLC v. Samsung Electronics America, Inc., et al.</i> , No. 2:23-cv-00285 (E.D. Tex.) filed June 16, 2023
1016	Amitabha Ghosh, 5G New Radio (NR): Physical Layer Overview and Performance, IEEE Communication Theory Workshop (May 15, 2018)
1017	<i>Cobblestone Wireless, LLC v. Samsung Electronics Co., Ltd.</i> , No. 2:22-cv-00285-JRG-RSP, Dkt. 29-1, Docket Control Order
1018	<i>Curriculum Vitae</i> of Dr. Kevin Almeroth

26. I also reviewed other materials I refer to in this Declaration in support of my opinions. My opinions contained in this Declaration are based on the documents I reviewed and my knowledge and professional judgment. My opinions have also been guided by my appreciation of how a person of ordinary skill in the art would have understood the state of the art, the prior art, and the claims and the specification of the '347 patent at the time of the alleged invention.

IV. LEGAL STANDARDS

27. Petitioners' attorneys have explained to me the legal standards that apply in this case. My understanding of those standards is described below. I am not an attorney, and I do not have formal training in the law regarding patents. I have used my understanding of the following legal principles set forth in this section in reaching

my opinions. I understand that, in this proceeding, Petitioners have the burden of proving that the challenged claims are invalid by a preponderance of the evidence.

A. Obviousness

28. I have been informed that a claim is invalid as obvious under 35 U.S.C. § 103 (pre-AIA) if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time of the invention to a person of ordinary skill in the art. I have been informed that the following matters are relevant to determining whether the claimed invention would have been obvious: (1) the scope and content of the prior art, (2) the difference or differences between the patent claim and the prior art, (3) the level of ordinary skill in the art at the time the invention of the patent, and (4) any secondary considerations or objective indicia of non-obviousness.

29. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. When a claim simply arranges prior art elements with each performing the same function it had been known to perform and yields no more than one would expect from such an arrangement, then such a combination is obvious. When a patent claims a structure already known in the prior art altered by the mere substitution of one element for another known in the field, the combination is likely to be obvious unless the combination yields an unpredictable result.

30. I have been informed that when a work is available in one field of endeavor, 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, such a variation is likely unpatentable. For the same reason, if a technique has been used to improve one device, and one of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. One question to consider is whether the improvement is more than predictably using prior art elements according to their established functions.

31. I have been informed that it may often be necessary, in a validity analysis, to consider whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue. This can be accomplished by looking to interrelated teachings of multiple patents or other publications or pieces of prior art; the effects of demands known to the design community or present in the marketplace; and the background knowledge possessed by one of ordinary skill in the art.

32. I have been informed that a validity analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim; it is appropriate to take account of the inferences and creative steps that a person of ordinary

skill in the art would employ. I have been informed that a person of ordinary skill in the art is a person of ordinary creativity, not an automaton.

33. I have been informed that a claim composed of several elements is not proved obvious merely by demonstrating that each element was, independently, known in the prior art. I have been informed that it can be important to identify a reason that would have prompted a person of ordinary skill in the art in the relevant field to combine the elements in the way the claimed new invention does. I am told that one way that subject matter can be proved obvious is by noting there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. I have been informed that any need or problem known in the field of endeavor at the time of the claimed invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

34. I have been informed that one should not assume that a person of ordinary skill in the art attempting to solve a problem will be led only to those elements of prior art designed to solve the same problem. Instead, I have been informed that since familiar items may have obvious uses beyond their primary purposes, in many cases a person of ordinary skill in the art will be able to fit the teachings of multiple prior art references together like pieces of a puzzle.

35. I have been informed that, when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable

solutions, persons of ordinary skill in the art have good reason to pursue the known options within their technical grasp. If this leads to the anticipated success, the product was likely not accomplished by innovation but by using ordinary skill and common sense. I have been informed that, in such an instance, the fact that the combination was obvious to try may show that the combination was obvious.

36. I have been informed that, when determining whether a claimed combination would have been obvious, the correct analysis is not whether a person of ordinary skill in the art, writing on a blank slate, would have chosen the particular combination of elements described in the claim. Instead, I have been informed that the correct analysis considers whether one of ordinary skill, facing the wide range of needs created by developments in the field of endeavor, would have seen a benefit to selecting the combination claimed.

37. I have been informed that, when determining whether a claimed invention is obvious, any “secondary considerations” of non-obviousness identified by the patentee should also be considered. These secondary considerations can include:

- commercial success of the invention, causally related to the invention itself rather than to companion factors, such as advertising or attractive packaging;
- the invention taught away from the technical direction followed by those skilled in the art;

- a long-felt but unsatisfied need for the invention while the needed implementing arts and elements had long been available;
- the invention achieves results unexpected to those skilled in the art;
- copying of the invention by competitors as distinguished from their independent development
- unsuccessful attempts by those skilled in the art to make the invention;
- acquiescence by the industry to the patent's validity by honoring the patent through taking licenses or not infringing the patent, or both; and
- skepticism, disbelief in or incredulity by those skilled in the art that the patentee's approach worked.

38. I have been informed that, for the above information to impact the obviousness of a patent claim, there must be a nexus between the alleged secondary considerations and the claims. In addition, I have been informed that the burden of introducing evidence of secondary considerations generally is on the Patent Owner. If the Patent Owner or its expert should assert secondary considerations of non-

obviousness, I reserve the right to provide a Declaration addressing assertions of non-obviousness due to secondary considerations.

B. Claim Construction

39. I have been informed that claim terms are typically given their plain and ordinary meanings, as would have been understood by a person of ordinary skill in the art at the time of the earliest alleged priority date. I have further been informed that when considering the meaning of any terms in the Challenged Claims of the '347 patent, I should apply the plain and ordinary meaning of those terms. I have further been informed that in considering the meaning of the claims, one must consider the language of the claims, the specification, and the prosecution history of record.

40. I have been informed that in general, a preamble limits the invention if it recites essential structure or steps, or if it is necessary to give life, meaning, and vitality to the claim. I have further been informed that a preamble is not limiting where a patentee defines a structurally complete invention in the claim body and uses the preamble only to state a purpose or intended use for the invention. I have further been informed that dependence on a particular disputed preamble phrase for antecedent basis may limit claim scope because it indicates a reliance on both the preamble and claim body to define the claimed invention. I have further been informed that clear reliance on the preamble during prosecution to distinguish the claimed invention from the prior

art transforms the preamble into a claim limitation because such reliance indicates use of the preamble to define, in part, the claimed invention.

V. PERSON OF ORDINARY SKILL IN THE ART AND THE TIME OF THE ALLEGED INVENTION

41. I have been asked to assume that the '347 patent is entitled to its earliest alleged priority date of July 28, 2011. See Ex. 1001. Beyond this assumption, I have not undertaken an analysis to determine the earliest priority date to which the '347 patent is entitled. I have reviewed Mr. Proctor's opinion on the definition of a POSITA and adopt it as my own. Further, based on the materials and information I have reviewed and based on my experience in the technical areas relevant to the '347 Patent, a person of ordinary skill in the art at the time of the alleged invention of the '347 Patent would have had at least a bachelor's degree in electrical engineering, computer engineering, computer science, physics, or the equivalent, and at least two years of experience working in the field. Relevant working experience would include experience with cellular telecommunications and networking, radio-access network architectures, protocols, and signal propagation in wireless networks. More education can supplement practical experience and vice versa. Based on my knowledge and experience, including as discussed above in section II, I was a person of ordinary skill in the art at the time of the alleged invention of the '347 Patent and can provide opinions regarding the knowledge of a person of ordinary skill in the art as of that time. My opinions herein are, where appropriate, based on my understandings as to a person

of ordinary skill in the art at that time. I myself had these capabilities at the time of the alleged invention of the '347 patent.

VI. THE '347 PATENT

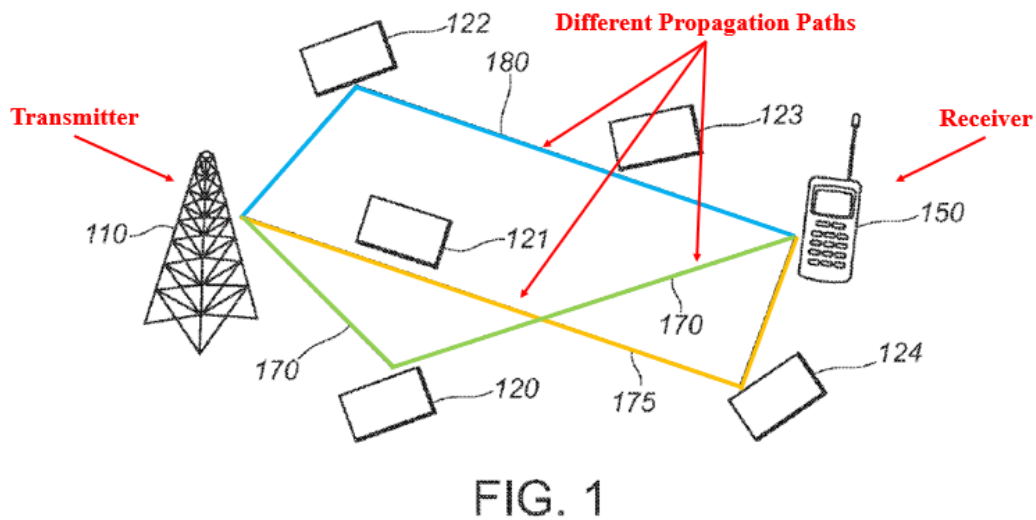
A. Description of the '347 Patent's Specification

42. I have reviewed Dr. Proctor's description of the '347 Patent and generally agree with how he has characterized the patent specification. The '347 Patent describes a pre-distortion technique that can be used for wireless data transmissions in wireless communication systems such as Long-Term-Evolution (LTE)-Advanced and ad-hoc wireless networks (*e.g.*, vehicular wireless networks). Ex. 1001 at 12:54-58. The '347 Patent explains that wireless communications systems are faced with numerous challenges. *Id.* at 1:6-7. For example, the '347 Patent explains that one of these challenges occurs when co-located heterogeneous networks create interference and difficulties in inter-network handover. *Id.* at 1:9-11. The '347 Patent identifies several existing techniques that have been developed to address these challenges in wireless communication systems, such as, relay techniques and coordinated multi-point (CoMP) transmission. *Id.* at 1:11-14. Both of these techniques operate by increasing the number of parallel channels between a source of a signal (*e.g.*, a transmitter) and a destination for the signal (*e.g.*, a receiver) to improve performance of the wireless communication system. *Id.* at 1:14-17.

43. Another commonly used technique identified by the '347 Patent is channel equalization. *Id.* at 1:22-26. The '347 Patent explains that channel equalization techniques are used by a receiver to recover a transmitted signal by removing distortion that occurs during transmission. *Id.* at 24-26. More specifically, channel equalization enables the receiver to phase align and constructively combine signals that arrive at the receiver from different paths. *Id.* at 1:27-29. Examples of channel equalization techniques include the RAKE receiving technique, the frequency equalization technique, and the time-frequency equalization technique known to be used in prior art TD-LTE systems. *Id.* at 1:30-37.

44. The '347 Patent explains that the problem with channel equalization techniques is that these operations are performed at the receiver which means that the receiver needs to have additional resources for performing the equalization. *Id.* at 1:38-41. To address this problem, the '347 Patent proposes a “pre-distortion” technique.

Figure A – Annotated Fig. 1 of '347 Patent



45. Figure 1 of the '347 Patent, illustrated above, is an example of wireless communication system that is configured for communications between a base station and a mobile station is shown. *Id.* at 3:23-26, Fig. 1. In this example, the base station (shown as element 110) is acting at the transmitter and the mobile station (shown as element 150) is acting as the receiver. *Id.* This example shows how the environment between the transmitter and receiver may cause signals between the transmitter and the receiver to scatter, diffract, reflect, and interact with different objects as they propagate, which results in these signals following different propagation paths (shown as elements 170, 175, and 180 (illustrated in green, orange, and blue above)). *Id.* at 3:26-30; *see also id.* at 7:38-44.

46. Having multiple propagation paths results in signals experiencing different delays, direction of arrival, direction of departure, and Doppler frequency

shifting as they propagate between the transmitter and the receiver. *Id.* at 3:47-48. One of the consequences of each signal experiencing different distortions along their respective propagation path is that the transmitted signals arrive at the receiver with different phases. *Id.* at 3:48-50 and 7:44-49. Having multiple copies of the originally transmitted signal with different phases means that these signals may combine constructively or destructively with each other at the receiver. *Id.* at 7:47-49.

47. Constructive interference occurs when two copies of the same signal are combined with the relative their phases sufficiently aligned such that the amplitude of the resulting combined signal is larger than each of the individual amplitudes. Conversely, deconstructive interference occurs when two copies of the same signal are combined with the relative their phases sufficiently mis-aligned such that the amplitude of the resulting combined signal is smaller than either of the individual amplitudes. In this case, when the signals are combined, the signals will tend to cancel each other out to at least some degree, and in some cases such cancelation is very significant (orders of magnitude). As an example, if two multipath signals (that is a common signal which arrives at the same location via two different propagation paths) are exactly 180° degrees out of phase and have the same amplitude (*i.e.*, have a 180°-degree phase shift between each other), then these signals will cancel each other out completely when they are combined. This interference or distortion can cause issues when a receiver

attempts to decode the data contained within the signals as the signals may have become corrupted or modified, leading to errors in the recovered information bits.

48. To avoid destructively combining signals, existing equalization techniques are used by receivers to remove distortions from the received signals to recover the originally transmitted signal. *Id.* at 7:50-51. After performing equalization, the signals at the receiver are phase aligned which allows these signals to then be added together constructively. *Id.* at 7:52-55.

49. The technique disclosed by the '347 Patent attempts to make wireless communications between the transmitter and the receiver more analogous to wired communications by mitigating or removing problems such as interference cancellation and capacity limitations at the transmitter. *Id.* at 3:38-43. More specifically, the '347 proposes a different technique from traditional equalization, where transmitted signals are modulated in such a way that they arrive at the receiver undistorted and with the same phase so they can be superimposed coherently (*i.e.*, combined constructively or “focused”). *Id.* at 3:50-58. The '347 Patent explains that the benefits of this proposed technique include a decrease in total transmission power due to energy efficiency increase, a reduction in interference among users which results in an improved quality of service, and a reduction in the need for multi-point cooperative technologies. *Id.* at 3:58-67.

50. Unlike equalization which occurs at the receiver, the process proposed by the '347 Patent involves adding pseudo distortion to a signal at the transmitter such that the distortion is removed as the signal propagates through a channel to the receiver. *Id.* at 7:63-8:3.

51. Figure 4 of the '347 Patent shown below illustrates steps for performing the pre-distortion technique of the '347 Patent.

Figure B – Fig. 4 of the '347 Patent

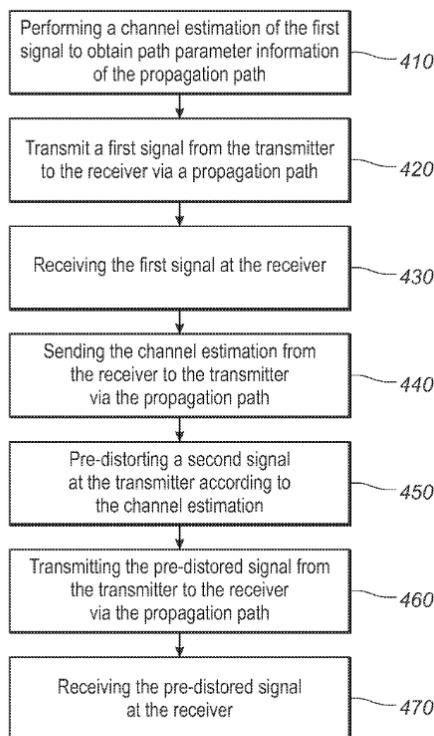


FIG. 4

52. Figure 4 of the '347 Patent illustrates a flowchart for the process proposed by the '347 Patent. This process involves the transmitter first transmitting a

first signal that to the receiver. *Id.* at 8:7-9. In this case, the first signal serves as a known reference signal that comprises distorted preambles or training sequences. *Id.* at 8:9-11. After receiving the first signal, the receiver then performs channel estimation on the first signal to determine parameters or channel information associated with each of the propagation paths. *Id.* at 8:11-16. By performing channel estimation, the receiver is able to obtain parameters and channel information such as a delay, a Doppler frequency shift, a direction of arrival, a direction of departure, and a complex amplitude for each of the propagation paths. *Id.* The '347 Patent provides numerous examples of techniques that can be used for performing channel estimations. *Id.* at 8:17-67.

53. After performing channel estimation, the receiver sends feedback about the determined channel estimation information to the transmitter. *Id.* at 9:1-5. The receiver sends the feedback to the transmitter along the respective propagation path for each of the transmitted first signals. *Id.* After receiving the channel estimation information from the receiver, the transmitter then uses the channel estimate information to pre-distort a second signal in the time domain, frequency domain, and spatial domain that is transmitted to the receiver. *Id.* at 9:6-12, 12:33-35. Applying the pre-distortion to the second signal in all three domains generates a signal that is transmitted with appropriate settings for transmission time, transmission pace and direction, receiving directions and complex weights of the signal (producing multiple

pre-distorted signal replicas which are combined and transmitted). *Id.* After, the transmitter transmits the pre-distorted second signal to the receiver. *Id.* 9:12-14.

54. The '347 Patent explains that the benefit of the proposed pre-distortion technique is that the pre-distortion which is added by the transmitter will be automatically removed during transmission and channel propagation. *Id.* at 9:49-54. In this way, the channel itself acts as an equalizer. *Id.* As the pre-distorted signals propagate along their respective propagation paths, they become phase aligned by the time they arrive at the receiver, which results in the signal constructively combining at the receiver without performing equalization at the receiver. *Id.* at 9:54-56.

55. The '347 Patent also explains that its path parameter information is not like the conventional channel estimate information that is used in conventional precoding techniques. Ex. 1001 at 11:60-12:2. Rather, the '347 Patent differentiates itself from these conventional techniques by disclosing that a full-dimensional parametric description of the channel is utilized which is more accurate than using traditional codebooks. *Id.* As an example of such full-dimensional parametric information, the '347 Patent identifies parameters that include delay, Doppler frequencies, direction of departure, and direction of arrival. *Id.* at 11:66-67.

56. The '347 Patent further explains that a receiver may consider channel estimation information describing the propagation path with respect to the frequency domain, the time domain, and the spatial domain. *Id.* at 9:67-10:9. More specifically,

the '347 Patent states that the receiver may consider information about delays for each path for synchronizing transmissions through different paths. *Id.* The receiver may also consider Doppler frequency for synchronizing transmissions. *Id.* Additionally, the receiver may consider directions of departure for signals aligned in the input of multiple antennas at the transmitter side. *Id.* Furthermore, the receiver may also consider directions of arrival at the output of multiple antennas at the receiver side. *Id.*

B. The '347 Patent's Prosecution History

57. I have reviewed the prosecution history of the '347 Patent. I have also reviewed Dr. Proctor's description of the '347 Patent's prosecution history, and have found it to be accurate. In the first Non-Final Office Action, the Patent Office rejected Claims 1, 8, 12, 16, 19, 21, 25, 28, and 32 of the '347 Patent as being anticipated by U.S. Patent Application Publication No. 2007/0177551 to Joham ("Joham") under 35 U.S.C. §102(b). Ex 1002 at 95. The Patent Office also rejected Claim 9 of the '347 Patent as being unpatentable over Joham in view of U.S. Patent Application Publication No. 2010/0177746 to Gorokhov ("Gorokhov"). *Id.* at 101.

58. In response to the Office Action with respect to Claim 1, Patent Owner distinguished the claims of the '347 Patent from Joham based on the claim element "predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain." Patent Owner argued that Joham only discloses compensating for spatial components and not distorting a signal in three domains (*i.e.*, the time

domain, the frequency domain, and the spatial domain as recited in claim 1). *Id.* at 79. Patent Owner further argued that independent Claims 12, 21, and 28 and their corresponding dependent claims are also allowable for analogous reasons. *Id.* Patent Owner also further argued that Claim 9 is also allowable since Claim 9 depends from Claim 1. *Id.* at 80.

59. In response to Patent Owner's remarks, the Patent Office issued a Notice of Allowance ("NoA") thereafter. *Id.* at 46. In the Notice of Allowance, the Examiner noted that Joham failed to specifically teach "wherein the predistorting is performed in each of the time domain, frequency domain, and the spatial domain." *Id.* at 49, 51, 53, 55.

C. Interpretation of the '347 Challenged Claims

60. I have reviewed Mr. Proctor's Declaration with respect to claim construction, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation. For the purposes of my analysis in this IPR proceeding, I understand that the words of a claim are given their plain meaning that those words would have had to a POSITA at the time of the alleged invention. I also understand that the structure of the claims, the specification, and the prosecution history may also be used to better construe a claim insofar as the plain meaning of the claims cannot be understood. Moreover, I understand that even treaties and dictionaries may be used, albeit under limited

circumstances, to determine the meaning attributed by a POSITA to a claim term at the time of filing. Furthermore, I understand that a Patent Owner's own apparent interpretation of certain terms in related proceedings can be considered to determine the meaning of patent claims in an IPR proceeding.

61. I have followed this approach in my analysis, and for all but two claim terms considered in this Declaration, I have applied the plain and ordinary meaning of those terms as they would have been interpreted by a POSITA at the time the invention was made (not today). For purposes of my analysis here, I have used the July 28, 2011 priority date of the '347 Patent as the date of the invention.

62. The two exceptions are for the terms: "path parameter information" and "predistorting a second signal at the transmitter in a time domain, frequency domain, and a spatial domain." While I understand that the Patent Owner has not formally provided proposed constructions, Patent Owner's infringement contentions (Exs. 1006, 1009, 1010, 1015) indicate to me that the Patent Owner has taken a broad interpretation of the claims that is not consistent with the plain and ordinary meaning that should be considered when assessing the validity of the Challenged Claims. As such, while I do not necessarily agree with these interpretations, I will consider them in rendering my below opinions.

1. “path parameter information”

63. In Patent Owner’s infringement contentions, Patent Owner is construing “path parameter information” broader than, and contrary to its plain and ordinary meaning. Specifically, it is seeking to construe the term to include any channel state information feedback, regardless of whether that channel state information is an explicit or implicit channel estimation. Ex. 1006 at 7-8; Ex. 1009 at 7-8; Ex. 1010 at 7-8; Ex. 1015 at 6-7. An implicit estimation is not path parameter information as a POSITA would understand the term in the ’347 Patent. *See e.g.*, Ex. 1001 at 11:60-12:6 (“ . . . the system and methods described above make use of the parameters of the propagation channel, e.g. the delay, Doppler frequencies, directions of departure and directions of arrival. This full-dimensional parametric description of the channel can be much more accurate than using the codebooks. . . .”), 14:18-21 (“Additionally, the systems and methods described herein make use of the parameters of propagation instead of the simplified channel status information, and thus, the focus resulted can be highly concentrated.”).

64. As stated above and explained by the ’347, a codebook value is not a “parameter of propagation,” but “simplified channel status information.” A POSITA would understand that the selection of a codebook is not a direct (*e.g.*, explicit) measurement of the channel, but a value which is usable to optimize the reception of a signal at the mobile device. However, such a codebook is an implicit measurement

because conditions of the channel may be implied by the value of the codebook. Similarly, a measured “signal to noise ratio” (SNR) is related to a signal condition after having been received through the path (an implicit measurement), but is not a “explicit” measurement of the path because the transmission power of the signal must also be known to determine the loss of signal along that path (*e.g.*, path loss—a direct path parameter). Thus, a POSITA would understand that implicit measurements can be used to “imply” the condition of the path but are not measurements of the path itself such as doppler, delay, and directions, or even path loss as I have explained. Below, I will provide more explanation relating to the implicit and explicit channel feedback in relation to the Sesia Reference (Ex. 1003).

65. Patent Owner alleges that User Equipment (UE) obtains path parameter information when “the UE performs link channel state estimation based on the first signal.” Ex. 1006 at 7; Ex. 1009 at 7; Ex. 1010 at 7; Ex. 1015 at 6. The Patent Owner then points to the implicit estimations of channel state based on the Channel State Information-Reference Signal (CSI-RS). Specifically, Patent Owner points to 3GPP TS 38.300 v17.2.0 at section 5.2.5.1,² which explains that “for channel state

² Patent Owner cites 3GPP TS 38.200 v2.0.0, § 5.2.5.1, however 3GPP TS 38.200 is not an actual standard, and I assume this was a typographical error. The portion

estimation purposes, the UE may be configured to measure CSI-RS and estimate the downlink channel state based on the CSI-RS measurements.” Ex. 1006 at 8; Ex. 1009 at 8; Ex. 1010 at 8. The estimated channel state values based upon the CSI-RS measurements in 5G (the alleged path parameter information) are generally simplified representations of the channel, not specific parameters such as delay, Doppler frequencies, directions of departure and directions of arrival. *But see* Ex. 1001 at 11:60-12:6, 14:18-21. In other words, these CSI-RS measurements (the alleged path parameters) are implicit measurements of the channel (such as codebooks) not explicit measurements.

66. Under this infringement read, Patent Owner is apparently interpreting the claims such that any information estimating the downlink channel state is “path parameter information,” regardless of whether it is simplified, explicit, or a full-dimensional parametric description. Ex. 1001 at 8:11-16, 11:62-12:6, 14:18-21. As will be shown below, in my opinion Sesia discloses this limitation under either the plain meaning or Patent Owner’s apparent interpretation.

copied in Patent Owner’s infringement contentions appears to be from section 5.2.5.1 of 3GPP TS 38.300 v17.2.0, which I have cited here.

2. “predistorting a second signal at the transmitter in a time domain, frequency domain, and a spatial domain”

67. Based on my review of the Patent Owner’s infringement contentions in the related district court proceedings, it appears to me that Patent Owner is interpreting “predistorting a second signal at the transmitter in a time domain, frequency domain, and a spatial domain” as beamforming a wireless signal. Ex. 1006 at 9; Ex. 1009 at 9; Ex. 1010 at 9; Ex. 1015 at 8) (“a 5G NR signal with beamforming is a predistorted signal in time, frequency, and space.”). Patent Owner further alleges that “applicable time and frequency subcarriers are selected based on the returned CSI, and an appropriate spatial beam refinement is selected based on the returned CSI.” *Id.* The Patent Owner apparently also accuses the selection of transmission resources by the base station to be a form of predistortion in the time domain and the spatial domain stating, “[i]n this illustration, a resource block is placed in a particular subframe (by time) and resource block (by frequency, i.e. subcarriers).” Ex. 1007 at 10; Ex. 1009 at 10; Ex. 1010 at 10; Ex. 1015 at 9. Along with the above explanation, which I have reviewed from Mr. Proctor’s Declaration and adopt as consistent with my own opinions, I further note that Patent Owner’s infringement contentions also include signal precoding, as they cite to a presentation that states the beamforming is accomplished using “digital precoding at baseband,” including precoding that is “CSI-RS based,” CSI being what Patent Owner accuses of infringing the channel estimation limitation. Ex. 1016 at 23; Ex. 1015 at 8 (relying on Exhibit 1016).

68. I do not necessarily agree that the selection of time and frequency resources and that beamforming are jointly or individually predistortion, but, under Patent Owner's apparent interpretation, the claim must be broad enough to capture the resource selection and beamforming of a wireless signal. I note that the Patent Owner provides no other accusations in its infringement contentions (Ex. 1007 at 9-10; Ex. 1009 at 9-10; Ex. 1010 at 9-10; Ex. 1015 at 8-9) as to how they believe these limitations are met. Therefore, I will consider the patent owner's apparent interpretation of this term in my analysis below. As will be shown below, in my opinion Sesia renders obvious this limitation under Patent Owner's broader interpretation.

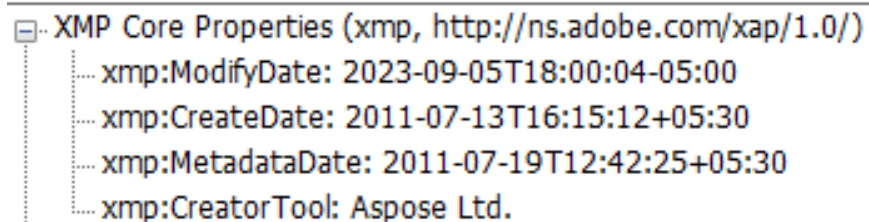
VII. SUMMARY OF THE PRIOR ART

A. Sesia (Ex. 1003)

69. I have reviewed Dr. Proctor's description of Sesia and have found it to be accurate. The '347 Patent is directed to a system for use within conventional and future wireless communications systems, such as an LTE and LTE-Advanced wireless communication system. Sesia describes the same wireless communication systems in extensive detail. Ex. 1001 at 12:54-62; Ex. 1003 at xxix-xxx. Sesia was published by John Wiley & Sons, Inc. ("Wiley") on the "Wiley Online Library" on July 22, 2011, which is before the effective filing date of the '347 Patent. *See* Ex. 1004, ¶¶17-22; *see also* Ex. 1013. I am personally familiar with the Wiley and their "Wiley Online Library." In my experience, Wiley is a well-known, reputable compiler and publisher

of scientific and technical publications, and members in the scientific and technical communities who both publish and engage in research rely on information published by Wiley and on its website. As such, a POSITA would take the “First published” date provided on the Wiley Online Library website as a reliable date indicative of a given reference’s publication status. The above explanations were taken from Mr. Proctor’s Declaration, which I adopt as my own as consistent with my opinions. I further note that Exhibit 1003 is a true and correct copy of Sesia as obtained from the Wiley Online Library. I also note that, besides the date listed on the Wiley Online Library, the metadata for the PDF of Exhibit 1003 indicates that the document was created on July 13, 2011, and that the metadata was created on July 19, 2011, both of which corroborate the July 22, 2011 publication date (see image below). Also, the DOI (digital object identifier) of Sesia, as listed on the Wiley Online Library, is 10.1002/9780470978504. A DOI is an identifier defined by ISO 26324 used for identifying documents, especially academic papers. The DOI system is managed by the well-known non-profit International DOI Foundation, whose website is www.doi.org, which allows any member of the public to enter a DOI identifier to retrieve the object (usually a website URL) attached to the identifier. Sesia’s DOI resolves to the URL of the Wiley Online Library’s page for the Sesia publication. A DOI can be registered using a third-party registration agency. Sesia’s DOI was registered with CrossRef, a non-profit organization that allows members to “create metadata records that identify, describe,

and locate their work.” See <https://www.crossref.org/membership/>. According to CrossRef, Sesia’s DOI is for an “EDITED BOOK published 22 July 2011.” See https://search.crossref.org/?from_ui=yes&q=10.1002%2F9780470978504). This further corroborates that Sesia was publicly available by at least July 22, 2011.



70. Sesia is a collaborative work that is authored by numerous telecommunication experts that have thorough knowledge and experience with wireless communications systems and the standards-setting environment, 3rd Generation Partnership Project (3GPP). Ex. 1003 at xxvii; *see also id.* at xxiii-xxv. In general, Sesia provides a “thorough, authoritative and complete tutorial” of LTE and LTE-Advanced communications systems. Ex. 1003 at xxvii. The goal of Sesia is to provide “an explanatory course through the LTE specifications, to support those who design LTE equipment.” Ex. 1003 at xxx. Sesia explains that the LTE specifications “are a record of decisions taken – decisions which are often compromises between performance and cost, theoretical possibility and practical constraints.” Ex. 1003 at xxx. As such, Sesia is written in such a way to give its reader detailed insight into the evaluations and trade-offs behind technology choices that are inherent to LTE and LTE-Advanced communications systems. *Id.* For example, Sesia is written to provide

a detailed explanation and tutorial of the theoretical understanding and practical techniques that are used in LTE and LTE-Advanced communication systems. *Id.* at xxvii.

71. In addition, Sesia provides comprehensive discussions over various aspects of LTE and LTE-Advanced communications systems including the requirements and targets for LTE, technologies for LTE, the LTE network architecture, Orthogonal Frequency-Division Multiplexing (OFDM), Orthogonal Frequency Division Multiple Access (OFDMA), downlink physical layer design, reference signals and channel estimation, link adaptation and channel coding, multiple antenna techniques, multi-user scheduling and interference coordination, uplink physical layer design, uplink physical channel structure, the radio propagation environment, LTE system performance, LTE-Advanced, beamforming, multiple antenna techniques for LTE-Advanced, Multiple-Input Multiple-Output (MIMO), and more. *Id.* at vii-xx.

72. Before discussing the Challenged Claims in detail, below I will summarize some of the relevant aspects of LTE discussed by Sesia:

1. Signal Propagation in LTE

73. In communication systems, a base station (referred to as an eNodeB in LTE) communicates with one or more mobile devices or user equipment (“UE”). Ex. 1003 at 438-39.

74. The concept of propagation refers to how signals move through the environment. Thus, in designing wireless systems, it is important to consider how signals propagate through the environment. Ex. 1003 at 438-39. Sesia explains how propagation can differ based on the environment. Rural, suburban, urban, and indoor settings each present different challenges. Ex. 1003 at 437. In addition, features of the device could impact propagation. For example, the propagation of signals is impacted by the type of antenna that is used. *Id.* at 437-38.

75. Figure C shows an annotated Figure 20.1 of Sesia, which illustrates several propagation paths that exist when performing wireless communications between a transmitter (*e.g.*, an eNodeB with an omnidirectional antenna) and a receiver (*e.g.*, a UE). Ex. 1003 at 438-39. In Figure C these propagation paths are shown as Paths 1 (orange), 2 (blue), and 3 (green)). Ex. 1003 at 438-39. Each of these propagation paths are capable of carrying a signal that is transmitted by the transmitter to the receiver. *Id.* at 437-39.

Figure C – Annotated Figure 20.1 of Sesia (Ex. 1003)

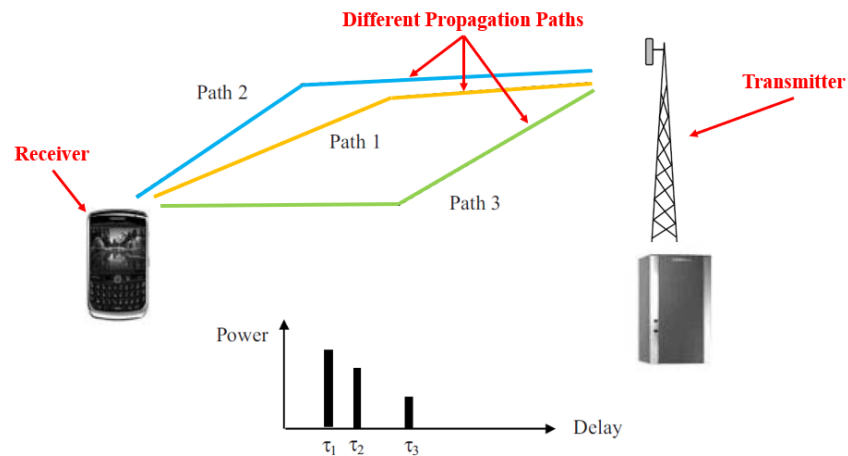


Figure 20.1: Multipath propagation and PDP.

76. As signals travel across these different propagation paths between the transmitter and the receiver, the signals will each be impacted by its given path in some way. Ex. 1003 at 438-39. For example, the signals on each path may reach the receiver at different times (*i.e.*, they may have different delays). *Id.* As a further example, the Path 3 signal may reach the UE before the Path 1 signal and Path 2 signal. Furthermore, the characteristics of these different propagation paths may also affect the signals in the frequency and space domain in addition to the time domain. Ex. 1003 at 438-39. These different propagation paths are created by and impacted by the environment. For example, reflection or diffraction caused by buildings, trees, cars, or other physical objects could alter the propagation paths.

77. As another example, Sesia discloses that in Multiple Input Multiple Output (MIMO) wireless communication systems, such as those used in LTE, the

transmitter and the receiver may each have a plurality of antennas that are used for transmitting signals. *Id.* at 252. Figure D shows an annotated Figure 11.2 of Sesia which illustrates the propagation paths that exist when transmitting signals between the transmitter with multiple antennas and the receiver with multiple antennas. *Id.* Similar to the previous example, each of these propagation paths is capable of carrying a signal that is transmitted by the transmitter to the receiver.

Figure D – Annotated Figure 11.2 of Sesia (Ex. 1003)

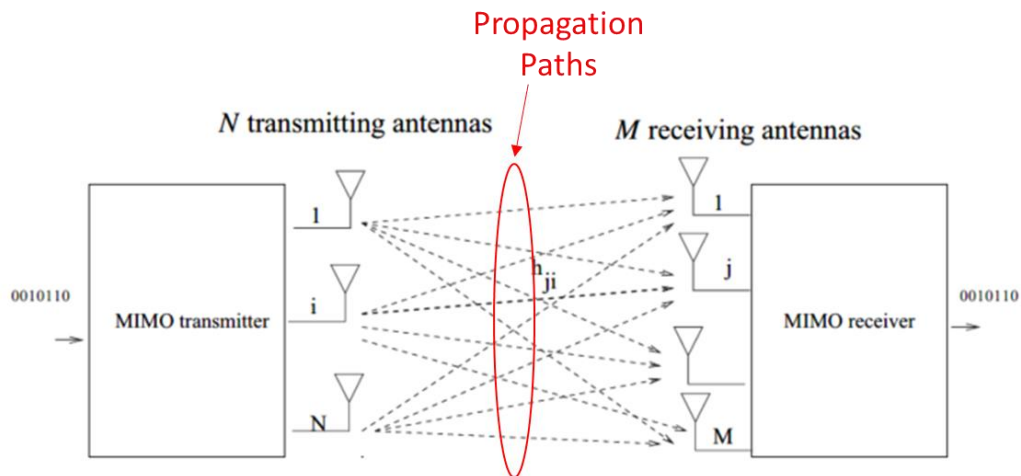


Figure 11.2: Simplified transmission model for a MIMO system with N transmit antennas and M receive antennas, giving rise to an $M \times N$ channel matrix, with MN links.

2. Signaling in LTE

78. Sesia provides significant detail regarding the operation of the physical layer in LTE. Ex. 1003 at Part 2 and Part 3. The physical layer defines the types of signals, format of signals, and timing of signals that can be transmitted over the air in an LTE system.

79. A key part of the physical layer description is the explanation of the channels used and the types of signals transmitted. Ex. 1003 at 149; *see also id.* at Chpt. 9. For example, LTE defines a number of channels for transmission of data and control information to a UE. *Id.*

80. Another type of signal that is described in detail in Sesia related to physical layer procedures is a reference signal. *See* Ex. 1003 at Chpt. 8 (titled “Reference Signals and Channel Estimation”). A reference signal is a signal having known attributes that does not carry any unknown data values. Ex. 1003 at 166-68, 651-57. Sesia explains that a reference signal may be a known symbol sequence or arrangement that is inserted into a signal structure that is transmitted to a UE. *Id.*; *see also id.* at 165-768 and 651-57. Sesia discloses several examples of reference signals that are used for channel estimation in LTE downlink, which include cell-specific reference signals, UE-specific reference signals, Multimedia Broadcast multicast service Single Frequency Network (MBSFN)-specific reference signals, Positioning reference signals, and Channel State Information (CSI) reference signals (CSI-RS). *Id.* at 167.

81. As an example, Sesia discloses that CSI-RSs were introduced in Release 10 specifically for the purpose of estimating the downlink channel state. *Id.* As another example, Sesia discloses that cell-specific reference signals can be transmitted to and used by a UE to perform channel estimation for demodulating data

and deriving feedback on the quality and spatial properties of the downlink radio channel. *Id.* at 651.

82. Sesia provides a schematic diagram of exemplary steps involved in the formation of a downlink LTE signal. Ex. 1003 at 148. These steps include modulation mapping, layer mapping, precoding, and OFDM signal generation.

Figure E – Figure 6.3 of Sesia (Ex. 1003)

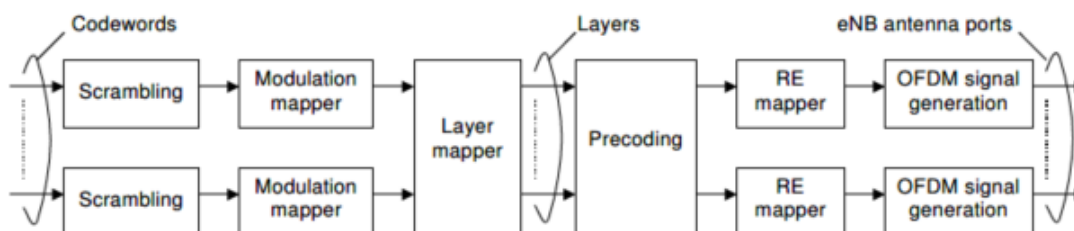


Figure 6.3: General signal structure for LTE downlink.
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83. The precoding stage is the point at which the signals may be adjusted based on a defined “codebook” with what is known as a “precoding matrix.” Ex. 1003 at 266-268. The precoding matrix alters the signal so that it is better able to exploit the channel (or paths) it is sent along by altering the signal in certain ways. *Id.*

84. With regard to the detection of signals, LTE was designed to use coherent detection of signals. Ex. 1003 at 165-66. Coherent detection exploits knowledge of channel conditions to improve detection. Ex. 1003 at 165-66. For example, coherent detection is able to leverage the phase and amplitude of a signal whereas non-coherent detection can only make use of the amplitude. *Id.* Sesia explains

that “[o]ptimal reception by coherent detection therefore typically requires accurate estimation of the propagation channel,” and “[a] common and simple way to estimate the channel is to exploit known signals which do not carry any data.” *Id.* Sesia further explains, that “[i]n order to estimate the channel as accurately as possible, all correlations between channel coefficients in time, frequency and space should be taken into account.” *Id.* at 166. Reference signals in LTE are used to allow a UE to perform these estimations. Ex. 1003 at 166-68.

85. Sesia further discloses that the usage of reference signals can be implemented by an eNodeB that has a single physical transmit antenna or multiple physical antenna elements. Ex. 1003 at 167. In addition, Sesia discloses that a UE can be configured to derive a channel estimate for all data transmitted on an antenna port regardless of whether it represents a single radio channel from a physical antenna or a composite channel from multiple physical antenna elements. *Id.*

3. Channel Estimation using Refence Signals

86. Sesia also describes multiple methods of performing channel estimation, including estimations in the frequency-domain, the time-domain, and the spatial-domain. *See* Ex. 1003 at Chpt. 8.4 (discussing channel estimation based on frequency-domain characteristics.); Chpt. 8.5 (discussing channel estimation based on time-domain characteristics and explaining that the benefit of a time-domain channel estimation is the possibility to enhance a channel estimate by exploiting its time

correlation with a channel); Chpt. 8.6 (discusses channel estimation based on spatial-domain characteristics).

87. As shown in Figure F, Sesia provides a model of a simple communication system. *Id.* at 165. As disclosed in Sesia, “x” represents a transmitted signal that passes through a radio channel (shown as “H”) which experiences additive noise (shown as “n”) before being received at the receiver as (shown as “y”). *Id.*

Figure F – Figure 8.1 of Sesia (Ex. 1003)

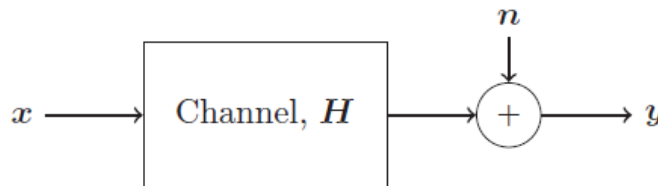


Figure 8.1: A simple transmission model.

88. Sesia also discloses a mathematical representation (*i.e.*, a transfer function) of the transmission model for a communication system. For example, Sesia discloses that the transmission model can be represented as:

$$r(t) = x(t) * h(t) + z(t) \quad (1)$$

where $r(t)$ represents a received signal at the receiver in a multipath environment, $x(t)$ represents a symbol transmitted at time instant t , $h(t)$ represents the continuous-time impulse response of the channel between a transmitter and a receiver, “*” represents the convolution operation, and $z(t)$ represents the additive noise. *Id.* at 127; *see also id.* at 131.

89. Sesia provides several examples of the types of issues that a transmitted signal may experience in the radio channel before being received at the receiver. For example, Sesia discloses that the relative speed between the transmitter and the receiver may generate a frequency error due to Doppler shifting. *Id.* at 133-34. As another example, Sesia discloses that a transmitted signal may experience a phase shift which corresponds with a time delay or a delay spread. *Id.* at 135-36.

90. Sesia continues by explaining that a common and simple way to estimate a channel is to use known signals (*i.e.*, reference signals). *Id.* at 166. As discussed above with respect LTE signaling, Sesia discloses that the transmitter transmits a reference signal, such as a CSI-RS, to the UE to perform channel estimation for deriving feedback on the quality and spatial properties of the downlink radio channel. *Id.* at 167 and 651.

91. Sesia describes how a UE can determine the transfer function (for example Equation 1 shown above) of channels from different antenna ports by making measurements on reference signals. *Id.* at 273. Sesia explains that the channel estimation problem is related to the physical propagation characteristics of a channel which may include the number of transmit and receive antennas, transmission bandwidth, carrier frequency, cell configuration, and the relative speed between the eNodeB and UE receivers. *Id.* at 174-75. Sesia further explains that, in general, the carrier frequencies and system bandwidth mainly determine the scattering nature of the

channel, the cell deployment governs its multipath, delay spread, and spatial correlation characteristics, and the relative speed sets the time-varying properties of the channel. *Id.* at 174-75.

92. Since the channel estimation problem is related to the physical propagation characteristics of a channel, Sesia discloses that downlink transmission resources in LTE possess dimensions of time, frequency, and space. *Id.* at 145-46; *see also id.* at 175. Sesia continues by explaining that in order to estimate the channel as accurately as possible, all correlations between the channel coefficients in time, frequency, and space should be taken into account. *Id.* at 166.

93. Sections 8.4, 8.5, and 8.6 of Sesia discuss methods to perform channel estimations in the frequency-domain, the time-domain, and the spatial-domain so as to obtain path parameter information for a given propagation path. For example, in Section 8.4 of Sesia, Sesia discusses performing channel estimation based on frequency-domain characteristics. *Id.* at 178-81. In this section, Sesia discloses a Channel Transfer Function (CTF) for the frequency-domain. *Id.* Notably, the disclosed Channel Transfer Function includes an element (shown as “**h**”) that corresponds with the Channel Impulse Response in the frequency-domain. *Id.* In Section 8.5 of Sesia, Sesia discusses performing channel estimation based on time-domain characteristics. *Id.* at 181-84. Sesia explains that the benefit of a time-domain channel estimation is the possibility to enhance a channel estimate by exploiting its time correlation with a

channel. *Id.* In Section 8.6 of Sesia, Sesia discusses performing channel estimation based on spatial-domain characteristics. *Id.* at 184-85. Sesia explains that it is assumed that an LTE UE has multiple receiving antennas, which provides an opportunity to correlate a channel in the spatial-domain to further enhance a channel estimate. *Id.*

94. In addition, Sesia states that the LTE specification does not mandate any specific channel estimation techniques and that there is complete freedom in implementation provided that the performance requirements are met, and the complexity is affordable. *Id.* at 185. Sesia even goes further and states that improvements to channel estimate techniques may be used which go beyond the example techniques described in Sesia. *Id.*

95. Sesia also explains that in performing channel estimation a receiver could provide two types of feedback to a transmitter regarding the path parameter information for the propagation path determined by channel estimation performed on a reference signal: implicit feedback and explicit feedback. Ex. 1003 at 274, 662-63. Sesia states that “[i]n Release 10, the same CQI/PMI/RI [[Channel Quality Indicator / Precoding Matrix Indicator / Rank Indicator]] feedback types are used as in Release 8.” Ex. 1003 at 662. And that “this is often described as *implicit* feedback, as it provides an implicit representation of the channel consisting of an indication of the data rate that could be achieved if the eNodeB used a certain precoder.” *Id.* In contrast, Sesia states with regard to explicit feedback measurements that “[t]he concept of implicit (i.e.

recommended precoder) feedback can be compared to what is sometimes called *explicit feedback* (not supported in LTE or LTE-Advanced), whereby a UE would instead explicitly report a quantized representation of the physical CSI without making assumptions about the nature of the eNodeB precoder.” *Id.* at 663. While Sesia discloses these two types of feedback, Sesia explains that ultimately explicit feedback was not adopted into Release 10 of the LTE 3GPP standard. *Id.*

96. The 3GPP LTE standard is a collection of detailed specifications that describe how LTE wireless communications system should work for both the UEs and the base stations. These specifications help to ensure that both systems operate in the same way and are thus interoperable with each other regardless of the manufacturer. The group that develops these specifications—the 3rd Generation Partnership Project (3GPP)—is comprised of many different members that come from various research institutions and industry partners. As such, the standardization process is an involved discussion by various parties that often involves the parties submitting various competing proposals for implementing a given functionality. Ultimately, the parties vote on what they believe to be the best proposal for a given functionality and that is the method that gets embodied in the standard/specification. However, in the process, many different approaches are considered through written proposals or technical reports in the open standards forum regardless of whether the specific technology is ultimately adopted at that time. In some cases, multiple equally good proposals are

made, at which point parties tend to just pick one for the sake of standardizing functionality.

97. From my review of some the standardization history for LTE, the use of explicit versus implicit feedback was discussed during the standardization process for Release 10 of the LTE specification. I believe this is likely one reason why Sesia discussed explicit feedback despite it not ultimately being adopted into the LTE 3GPP standard. For example, R1-101217 (Ex. 1007) and R1-100926 (Ex. 1008) are two exemplary documents submitted during the standardization process that show companies such as NTT Docomo and Alcatel-Lucent were discussing whether to utilize implicit or explicit feedback in Release 10.

98. In the case of implicit feedback, Sesia discloses that the UE makes a hypothesis on the precoder or the precoding the eNodeB would use for transmission and reports a recommended Precoding Matrix Indicator (PMI) which corresponds with the best hypothesis (*i.e.*, an implicit representation of the channel state information). Ex. 1003 at 274. In the case of explicit feedback, Sesia discloses that the UE explicitly reports a quantized representation of the physical channel state information without making assumptions about the nature of the eNodeB precoder. *Id.* at 663. Sesia also provides an example of using rank-1 explicit feedback. *Id.* In this example, Sesia explains that an explicit short-term channel state information report is provided that indicates the direction of the highest gain channel gain (*i.e.*, the strongest eigenvector

of the channel matrix). *Id.* Sesia further discloses that both implicit and explicit feedback schemes, under certain assumptions, have similar results. *Id.*

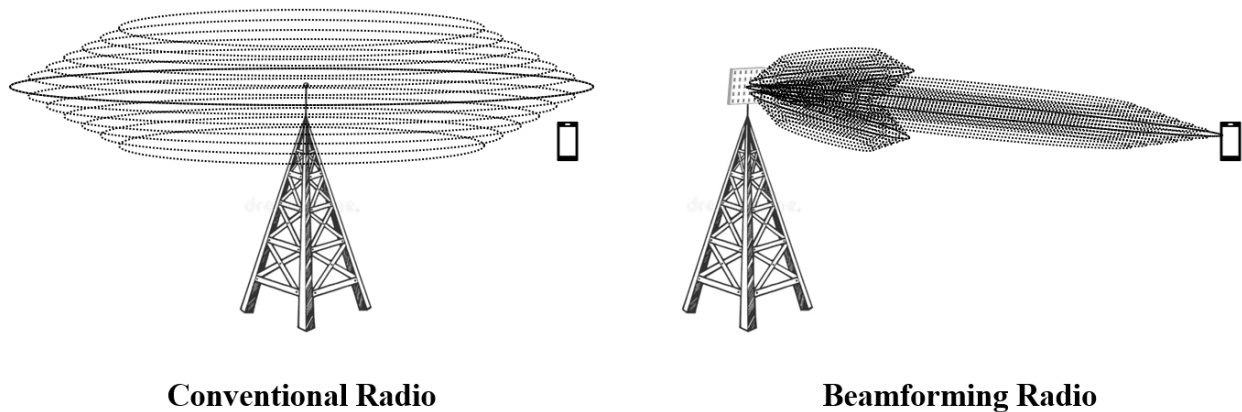
99. To further explain the difference between implicit and explicit feedback, it may be helpful to think of the following hypothetical example. In an implicit feedback system, for example, when a UE measures the signal-to-noise ratio and received power of a given signal, the UE may report a representation of the measurements to indicate the quality. For example, a UE may send a message such as “signal quality 5” to show that the quality is average. In this example, the UE makes an assumption that the base station and the UE are operating with the same coding scheme such that the base station knows how to interpret “signal quality 5” in terms of the estimated channel quality. In an explicit channel feedback system, however, when a UE measures the signal-to-noise ratio and received power of a given signal, the UE would calculate and report an attribute of the physical channel itself such as path loss, rather than a property of the received signal alone. In LTE, implicit feedback consists of multiple parameters (*e.g.*, Channel quality indicator “CQI,” Recommended Preceding index “PMI,” and Rank Indicator “RI”). *Id.* at 272.

4. Beamforming

100. At a high level, beamforming is a method that can be utilized to improve signal strength by focusing transmitted signals in a certain direction and ideally in a certain location. Beamforming is accomplished by utilizing constructive

and destructive combinations of a signal from different closely spaced antennas transmitting multiple copies of a signal with different phases and amplitudes to focus the beam in a given direction or at a specific location. The figure below shows an exemplary difference of the radiation patterns between a conventional (omnidirectional) radio and a radio performing beam forming (directional).

Figure G



101. As shown in Figure E (reproduced below), the steps involved in forming a downlink LTE signal on a carrier for channel encoding involves modulation mapping, layer mapping, precoding, and OFDM signal generation. Ex. 1003 at 148. Through these steps a transmitter can beamform a signal that is transmitted to the receiver based on the feedback and channel state information that is provided by the receiver.

Figure E – Figure 6.3 of Sesia (Ex. 1003)

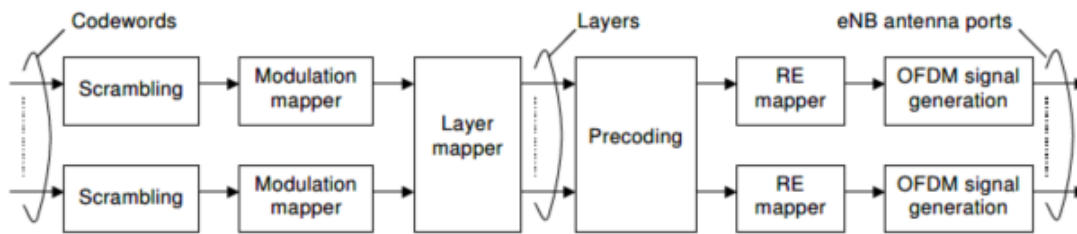


Figure 6.3: General signal structure for LTE downlink.
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102. Sesia discloses that, in LTE, the use of multiple antenna technology allows the transmitter and receiver to exploit the spatial-domain. Ex. 1003 at 15-16. Sesia provides several examples of the benefits that can be achieved when using multiple antennas which include diversity gain, array gain, and spatial multiplexing gain. *Id.* at 16. Sesia explains that using multiple antennas to provide spatial diversity improves the robustness of the transmission against multipath fading. *Id.* Sesia also explains that using multiple antennas provides array gain by concentration of energy in one or more directions via precoding and/or beamforming. *Id.* Sesia further explains that using multiple antennas to provides spatial multiplexing gain by transmitting multiple signal streams to a single user on multiple spatial layers that are created by the combinations of available antennas. *Id.* The use of multiple antennas is often referred to as Multiple Input Multiple Output (“MIMO”) when used with a receiving device having multiple antennas as well.

103. Sesia discloses that an optimal way of communicating over a MIMO channel involves a channel-dependent precoder, which fulfills the roles of both transmit beamforming and power allocation across the transmitted streams. *Id.* at 253. Sesia explains that this can be achieved if the transmitter has full channel knowledge. *Id.* Sesia explains that this channel knowledge comes from feedback about the propagation path(s) from the receiver based on channel estimation performed on reference signals. *Id.* at 263-64. In particular, Sesia discloses that a UE in LTE “can be configured to report Precoding Matrix Indicators (PMIs) and Rank Indicators (RIs), in addition to CQI [(Channel Quality Indicator)] reporting.” *Id.* at 272.

104. Sesia explains that the eNodeB is capable of computing and performing beamforming precoding when accurate channel state information is available and provided from the receiver. *Id.* at 263-64; *see also id.* at 271. In addition, Sesia discloses that, in general, scheduling algorithms can make use of the channel state information for making scheduling decisions. *Id.* at 280. Sesia further discloses that the scheduler uses the Channel Quality Information within the CSI from a UE to schedule radio resources for transmission in the frequency (subcarriers / Resource Blocks) domain, and the time (Sub-frame) domain. *Id.* at 279-81, Figure 12.2.

Figure H – Figure 12.2 of Sesia (Ex. 1003)

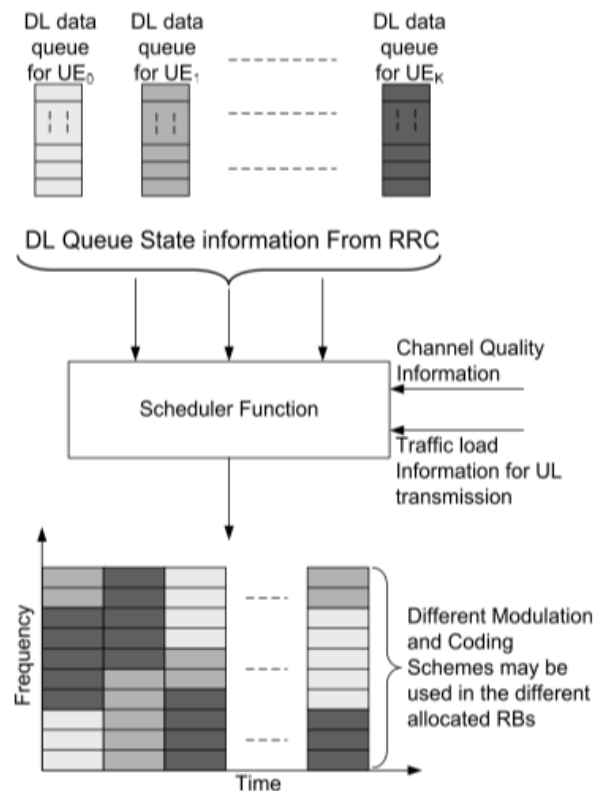


Figure 12.2: Generic view of a wideband resource scheduler.

105. One approach disclosed by Sesia is opportunistic scheduling, which is “designed to maximize the sum of the transmitted data rates to all users by exploiting the fact that different users experience different channel gains and hence will experience good channel conditions at different times and frequencies.” Ex. 1003 at 281. And based upon these differences in channel conditions, “allocating the channel at each given time instant only to the user with the best channel condition in a particular part of the spectrum can yield a considerable increase in the total throughput as the number of active users becomes large.” *Id.* at 282. This approach benefits from multi-

user diversity (*i.e.*, delaying scheduling of UEs in poor conditions and scheduling users at the present sub-frame who have reported good conditions). Ex. 1003 at 281-82. Sesia also discloses so-called frequency selective scheduling, in which the CQI reported for a sub-band of the channel can be used to select more optimal resources in the frequency domain. *Id.* at 346; *see also id.* at 327.

106. “A final important aspect of link adaptation is its use in conjunction with multi-user scheduling in time and frequency, which enables the radio transmission resources to be shared efficiently between users as the channel capacity to individual users varies. The CQI can therefore be used not only to adapt the modulation and coding rate to the channel conditions, but also for the optimization of time/frequency selective scheduling and for intercell interference management.” *Id.* at 216. The CQI reporting by the UE may be configured to report the channel quality in different portions of the channel. For example, Sesia teaches “[t]he UE reports a wideband CQI value for the whole system bandwidth. In addition, the UE reports a CQI value for each sub-band, calculated assuming transmission only in the relevant sub-band.” *Id.* at 221. Furthermore, PMI may be reported for both wideband (the entire channel) and for sub-band frequencies of the channels. *Id.* at 273.

107. Because the CSI information (including CQI) is utilized in the scheduler, and CQI is effected by the choice of precoder (*e.g.*, beamforming), the beamforming benefit effects the scheduling of the resources. “The eNodeB has to

adjust the MCS used for transmission relative to the CQI reports by estimating the expected beamforming gain depending on the number of transmitted layers.” Ex. 1003 at 272. The Modulation and Coding Scheme (MCS) determines the number of resources required to be scheduled to carry the transmission block(s). *Id.* at 217-19. Thus, the reported rank indicator (RI) is utilized to determine the number of layers (transmission blocks) to be scheduled, and the PMI is utilized to determine the beamformer’s CQI benefit associated with a particular resource in time and frequency when scheduling as discussed above.

108. Specific to the beamforming benefit, Sesia discloses two specific exemplary methods for performing beamforming: closed-loop rank-1 precoding and beamforming with UE-specific reference signals. *Id.* at 270. In closed-loop rank-1 precoding, Sesia explains that the receiver feeds channel state information back to the eNodeB to indicate suitable precoding to apply for beamforming operations. *Id.* The precoding matrix alters the signal so that the signal is better able to exploit the channel (or path) it is sent along by applying weights that alter the signal in various ways. *Id.* In closed-loop rank-1 precoding, the UE feeds channel state information (known as Precoding Matrix Indicators (PMIs)) back to the base station to indicate what precoding should be applied for beamforming. *Id.* The UE determines the PMIs it reports back to the base station based on channel estimations performed on the reference signals received from the base station. *Id.* at 272-274. Sesia also explains that

the eNodeB is not bound to use any precoder requested by the UE. *Id.* at 273; *see also id.* at 274. Sesia further explains that, in Release 9, the support for MU-MIMO was enhanced to remove the constraint on the eNodeB to use the feedback codebook for precoding and to give flexibility to utilize other approaches to MU-MIMO user separation. *Id.* at 275.

109. In beamforming with UE-specific reference signals, the signal is altered (*i.e.*, beamformed) based on channel state information to concentrate the base station “power in the directions in which the radio channel offers the strongest path(s) to reach the UE.” *Id.* at 270-271.

110. In Release 10, additional reference signals called CSI-RS were added for use in CSI reporting including for use with beamforming of up to 8 transmission antennas. *Id.* at 654.

111. Sesia explains that when designing an OFDM system, several propagation characteristics should be taken into account including expected delay spread, the maximum Doppler frequency, and cell size. *Id.* at 139; *see also id.* at 142. Sesia also discloses that the channel model that is used has to reflect all the instantaneous space-time-frequency characteristics which affect the configuration of diversity, beamforming, and spatial multiplexing techniques. *Id.* at 437-39. With regards to the time-domain, Sesia discloses that the required spacing in time between the reference symbols can be determined by considering the maximum Doppler spread

(highest speed) to be supported, the carrier frequency, doppler shift, and the speed of the UE. *Id.* at 169. With regards to the frequency-domain, Sesia discloses that the spacing related to coherent bandwidth of the channel is related to channel delay spread. *Id.* Sesia explains that in LTE, the spacing between two reference symbols in frequency, can be determined as a function of the maximum channel delay spread. *Id.* With regards to the spatial-domain, Sesia discloses that a typical usage of UE-specific reference signals is to enable beamforming of data to specific UEs. *Id.* at 171. Sesia explains that the eNodeB may use a correlated array of physical antenna elements to generate a narrow beam in the direction of a particular UE. *Id.* Sesia further explains that such a beam will experience a different channel response between the eNodeB and the UE. *Id.* Such a beamforming approach can be used to address distortion related to the spatial domain. *Id.*

112. As a reminder, Sesia explains that the UE transmits channel estimate information (*e.g.*, a Channel Quality Indicator) as feedback to the eNodeB via an uplink, which is then used by the eNodeB for selecting a modulation scheme and/or code rate. *Id.* at 215. Sesia states that the LTE specifications are designed to provide signaling that is necessary for the interoperability between the eNodeB and UEs so that the eNodeB can optimize the link adaptation and that the exact methods used by an eNodeB to exploit the information that is available are left to the manufacturer's choice of implementation. *Id.* at 215-16. These statements express the complete freedom the

transmitter has when determining how to best utilize the feedback provided by the UE for precoding and beamforming.

113. As demonstrated by Sesia and will be explained below, all of the claimed concepts of the Challenged Claims of the '347 Patent were well-known in the art prior to the effective filing date of the '347 Patent (or would have been obvious to a POSITA in light of the disclosures of Sesia).

B. Motivation to Combine

114. I have reviewed Mr. Proctor's declaration regarding motivation to combine, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation. For the following reasons, a POSITA would have been motivated to combine the different chapters and sections of Sesia. As explained above, Sesia is a collaborative work that is authored by numerous telecommunication experts that have thorough knowledge and experience with wireless communications systems and the standards-setting environment, 3rd Generation Partnership Project (3GPP). Ex. 1003 at xxvii; *see also id.* at xxiii-xxv. Furthermore, Sesia provides a "thorough, authoritative and complete tutorial" of LTE and LTE-Advanced communications systems. Ex. 1003 at xxvii. In addition, the goal of Sesia is to provide "an explanatory course through the LTE specifications, to support those who design LTE equipment." Ex. 1003 at xxx. As such, a POSITA would understand that the different chapters and sections of the Sesia are

meant to be read together, as together, they describe LTE and LTE-Advanced communications systems. Furthermore, Sesia is published as a single book that was edited together to provide “an explanatory course through the LTE specifications.” Ex. 1003 at xxx. As such, a POSITA would have been motivated to read all of Sesia together as one. Finally, a POSITA would have expected a reasonable likelihood of success in combining the different sections as each of the chapters and sections in Sesia were selected by the editors to provide said explanatory course in LTE and LTE-Advanced. As such, a POSITA would have been motivated to combine the different sections and chapters in Sesia together with a reasonable likelihood of success.

VIII. GROUND 1: SESIA RENDERS OBVIOUS CLAIMS 1-4, 6-12, 14-17, AND 19-23

A. Independent Claim 1

[1.0] A method for wireless communication in a system including a transmitter, a receiver, and a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver, the method comprising:

115. In my opinion, Sesia discloses and/or renders obvious “a system including a transmitter, a receiver, and a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I

find his explanation is consistent with my own opinions, so I have adopted his explanation.

116. Figure C shows an annotated Figure 20.1 of the Sesia, which illustrates a plurality of propagation paths that exist when performing wireless communications between a transmitter (*e.g.*, an eNodeB) and a receiver (*e.g.*, a UE). Sesia discloses that the plurality of propagation paths (shown as Paths 1 (orange), 2 (blue), and 3 (green)) occur when signals are transmitted between the transmitter and the receiver. Ex. 1003 at 438-39. Each of these propagation paths is capable of carrying a signal that is transmitted by the transmitter to the receiver. *Id* at 437-39.

Figure C – Annotated Figure 20.1 of Sesia (Ex. 1003)

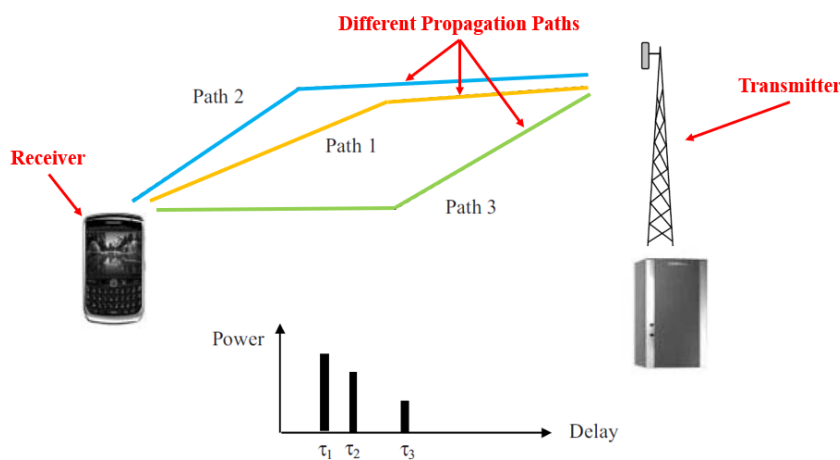


Figure 20.1: Multipath propagation and PDP.

117. As another example, Sesia further discloses that in Multiple Input Multiple Output (MIMO) wireless communication systems, such as those used in LTE, the transmitter and the receiver may each have a plurality of antennas that are used for

transmitting signals. *Id.* at 252. Figure D shows an annotated Figure 11.2 of Sesia which illustrates the propagation paths that exist when transmitting signals between the antennas of the transmitter and the antennas of the receiver. Similar to the previous example, each of these propagation paths is capable of carrying a signal that is transmitted by the transmitter to the receiver. A POSITA would thus understand that a plurality of propagation paths could be formed between the transmitter (base station) and a UE. As such, Sesia discloses a “method for wireless communication” based on the transmission of signals between the transmitter and the receiver.

Figure D – Annotated Figure 11.2 of Sesia (Ex. 1003)

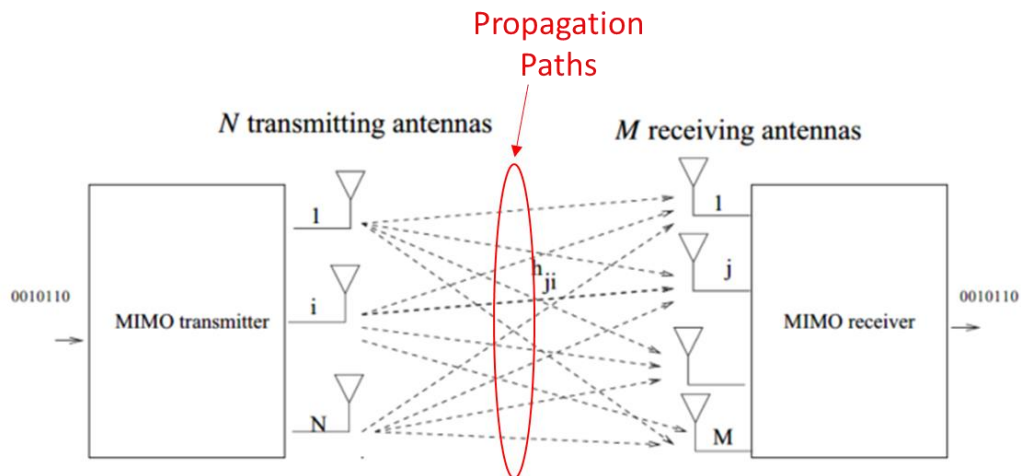


Figure 11.2: Simplified transmission model for a MIMO system with N transmit antennas and M receive antennas, giving rise to an $M \times N$ channel matrix, with MN links.

These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s Figures 20.1, 11.2 and their corresponding descriptions disclose this limitation.

[1.1] transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths;

118. In my opinion, Sesia discloses and/or renders obvious “transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

119. Sesia discloses that a common way to estimate a channel is to first transmit a known signal (*i.e.*, a reference signal) which does not carry unknown data. Ex. 1003 at 166. Sesia explains that a reference signal may be a known symbol sequence or arrangement that is inserted into a signal structure that is transmitted to a UE. *Id.*; *see also id.* at 168 and 651-57. Sesia discloses several examples of reference signals that are used for channel estimation in LTE downlink, which include cell-specific reference signals, UE-specific reference signals, MBSFN-specific reference signals, Positioning reference signals, and Channel State Information (CSI) reference signals (CSI-RS). *Id.* at 167. As an example, Sesia discloses that CSI-RSs were introduced in Release 10 specifically for the purpose of estimating the downlink channel state. *Id.* As another example, Sesia discloses that cell-specific reference signals can be transmitted to and used by a UE to perform channel estimation for

demodulating data and deriving feedback on the quality and spatial properties of the downlink radio channel. *Id.* at 651.

120. Sesia further discloses that each reference signal pattern is transmitted from an antenna port at the base station or eNodeB, which can be implemented as either a single physical transmit antenna or as a combination of multiple physical antenna elements. *Id.* at 167. Sesia continues by explaining that the UE is configured to derive a channel estimate for all data transmitted on an antenna port regardless of whether it represents a single radio channel from a physical antenna or a composite channel from a multiplicity of physical antenna elements together comprising the antenna port. *Id.*

121. As discussed above with respect to Figures C and D, when the transmitter transmits a signal to the receiver, the signal is transmitted along at least one of a plurality of propagation paths that exist between the transmitter and the receiver. In this case, the first signal is a reference signal that is transmitted by the transmitter along the at least one of the propagation paths that exist between the transmitter and the receiver. As such, a POSITA would understand that Sesia teaches transmitting a reference signal from an eNodeB to a UE via a propagation path. Thus, Sesia discloses and/or renders obvious “transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths,” as recited in Claim 1.

These explanations, which I have adopted from Mr. Proctor's Declaration, reflect my own opinion that the above descriptions from Sesia of a reference signal disclose this limitation.

[1.2] receiving the first signal at the receiver;

122. In my opinion, Sesia discloses and/or renders obvious "receiving the first signal at the receiver." I have reviewed Mr. Proctor's Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

123. As discussed above with respect to claim element **[1.1]**, Sesia discloses that a reference signal (*i.e.*, the first signal) is transmitted to the UE for channel estimation. *See e.g.*, Ex. 1003 at 167 and 651. Also as discussed above with respect to Figures C and D, the receiver will receive the reference signal transmitted by the transmitter via at least one of the plurality of propagation paths that exist between the transmitter and the receiver. As such, a POSITA would understand that in this case, the receiver receives the first signal, which is a reference signal, that is transmitted by the transmitter via at least one of the propagation paths that exist between the transmitter and the receiver. Thus, Sesia discloses and/or renders obvious "receiving the first signal at the receiver," as recited in Claim 1.

These explanations, which I have adopted from Mr. Proctor's Declaration, reflect my own opinion that Sesia's description of a reference signal transmitted to a UE discloses this limitation.

[1.3] performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path;

124. In my opinion, Sesia discloses and/or renders obvious "performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path." I have reviewed Mr. Proctor's Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation. As described above in Section VII (which is incorporated by reference herein) and discussed below, Sesia discloses and/or renders obvious performing channel estimation on a reference signal transmitted by an eNodeB to obtain path parameter information of a propagation path.

(i) Sesia discloses performing channel estimation on a reference signal.

125. Sesia discloses that a common and simple way to estimate a channel is to use known signals (*i.e.*, reference signals). Ex. 1003 at 165-7. As discussed above with respect to claim elements **[1.1]** and **[1.2]**, Sesia discloses that the transmitter transmits a reference signal, such as a CSI-RS, to the UE to perform channel estimation

for deriving feedback on the quality and spatial properties of the downlink radio channel. *Id.* at 167 and 651.

126. Sesia discloses that the UE can determine the transfer function, for example Equation 1 shown above and reproduced below, of channels from different antenna ports by making measurements on reference signals. *Id.* at 127, 131, and 273.

$$r(t) = x(t) * h(t) + z(t) \quad (1)$$

where $r(t)$ represents a received signal at the receiver in a multipath environment, $x(t)$ represents a symbol transmitted at time instant “ t ,” $h(t)$ represents the continuous-time impulse response of the channel, “ $*$ ” represents the convolution operation, and $z(t)$ represents the additive noise. *Id.* at 127; *see also id.* at 131.

127. Sesia discloses that the channel estimation problem is related to the physical propagation characteristics of a channel which may include the number of transmit and receive antennas, transmission bandwidth, carrier frequency, cell configuration, and the relative speed between the eNodeB and UE receivers. *Id.* at 216. Sesia explains that, in general, the carrier frequencies and system bandwidth mainly determine the scattering nature of the channel, the cell deployment governs its multipath, delay spread, and spatial correlation characteristics, and the relative speed sets the time-varying properties of the channel. *Id.* at 174-75.

128. Since the channel estimation problem is related to the physical propagation characteristics of a channel, Sesia discloses that downlink transmission

resources in LTE possess dimensions of time, frequency, and space. *Id.* at 145; *see also id.* at 175. Sesia continues by explaining that in order to estimate the channel as accurately as possible, all correlations between the channel coefficients in time, frequency, and space should be taken into account. *Id.* at 166. As such, Sesia discloses performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path.

129. As discussed above in Section VII, Sesia describes multiple methods of performing channel estimation, including channel estimations in the frequency-domain, the time-domain, and the spatial-domain. *See* Ex. 1003 at Chpt. 8.4, 8.5, and 8.6. For example, in Chapter 8.4, Sesia discusses performing channel estimation based on frequency-domain characteristics. Ex. 1003 at 178-81. In Chapter 8.5, Sesia discusses performing channel estimation based on time-domain characteristics and explains that the benefit of a time-domain channel estimation is the possibility to enhance a channel estimate by exploiting its time correlation with a channel. Ex. 1003 at 181-84. In the next section, Section 8.6, Sesia discusses performing channel estimation based on spatial-domain characteristics. Ex. 1003 at 184-85. Furthermore, Sesia explains that in order to estimate the channel as accurately as possible that all of the above methodologies should be utilized when performing channel estimation. *See* Ex. 1003 at 166 (“In order to estimate the channel as accurately as possible, all

correlations between channel coefficients in time, frequency and space should be taken into account.”).

130. In addition, Sesia discloses that the LTE specification does not mandate any specific channel estimation techniques and that there is complete freedom in implementation provided that the performance requirements are met, and the complexity is affordable. *Id.* at 185. Sesia even goes further and states that improvements to channel estimate techniques may be used which go beyond the example techniques described in Sesia. *Id.*

131. Sesia therefore discloses performing channel estimation on a reference signal.

(ii) Sesia discloses obtaining path parameter information from the channel estimation.

132. As discussed above, Sesia explains that the path parameter information that is determined from the channel estimation can be provided as either implicit feedback or explicit feedback. Ex. 1003 at 274-75, 662-63.

133. Sesia discloses several types of feedback information determined from the reference signals, which may be fed back to the base station. These include Precoding Matrix Indicators (“PMIs”) and Rank Indicators (“RIs”), and CQI reporting. Ex. 1003 at 272, 167. For example, Sesia discloses that the Precoding Matrix Indicator (PMI) is one type of feedback that can be sent to the eNodeB by the UE based on the channel estimation. Ex. 1003 at 272-274. Because PMI is selected based on a

hypothesis regarding the precoding that the eNodeB should use for transmissions along the propagation path, PMI is a form of implicit feedback. *Id.* at 274-75, 662-63. Furthermore, PMI is a form of implicit feedback because “it provides an implicit representation of the channel consisting of an indication of the data rate that could be achieved if the eNodeB used a certain precoder.” *Id.* at 662. In other words, PMI is not an explicit quantized measurement, but rather a representative number that informs the eNodeB of the precoding selected by the UE, from a codebook. Sesia also discloses that in Release 10, the channel state information is reported as a combination of Channel Quality Information, PMI, and Rank Indicator. *Id.* These reports are “often described as implicit feedback, as it provides an implicit representation of the channel consisting of an indication of the data rate that could be achieved if the eNodeB used a certain precoder.” *Id.* at 662-63.

134. Sesia also discloses how a UE could provide explicit feedback. *Id.* at 662-663. Explicit feedback involves reporting a quantized representation of the physical channel state information. *Id.* In other words, explicit feedback involves reporting the actual channel estimation measurements as opposed to other measurements which may be used to imply the channel indirectly. As a result, explicit feedback does not rely on any assumptions about the eNodeB such as what codebook the precoder in the eNodeB is utilizing. *Id.* Sesia also provides an example of incorporating using rank-1 explicit feedback into a system such as LTE or LTE-

Advanced. *Id.* In this example, Sesia explains that an explicit short-term channel state information report is provided that indicates the direction of the highest gain channel gain (*i.e.*, the strongest eigenvector of the channel matrix). *Id.* Sesia explains that both implicit and explicit feedback schemes can have similar results. Ex. 1003 at 663.

135. Based on Sesia's disclosure, a POSITA would understand, under the Patent Owner's apparent interpretation of the claims, that the information that is obtained from performing channel estimation on a reference signal and subsequently provided to the eNodeB by the UE as either implicit or explicit feedback corresponds with the claimed "path parameter information." Furthermore, under the Patent Owner's apparent interpretation of the claims, based on Sesia's disclosure, a POSITA would understand that this information is "path parameter information of the first propagation path" given that channel estimation attempts to define the channel model of a propagation path.

136. In Patent Owner's infringement contentions (Exs. 1006, 1009, 1010), Patent Owner identified the "path parameter information" as channel state information measured from the CSI-RS. As discussed above, Sesia discloses the same measurements for the same reference signal.

137. Thus, Sesia discloses and/or renders obvious "performing a channel estimation based on the first signal to obtain path parameter information of the first

propagation path,” as recited in Claim 1 under either Patent Owner’s apparent interpretation or the plain and ordinary meaning of the term.

These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of calculating various channel characteristics from the reference signal disclose this limitation.

[1.4] sending the channel estimation that includes the path parameter information from the receiver to the transmitter via the first propagation path;

138. In my opinion, Sesia discloses and/or renders obvious “sending the channel estimation that includes the path parameter information from the receiver to the transmitter via the first propagation path.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

139. As discussed above with respect to claim element **[1.3]**, Sesia discloses performing a channel estimate on a reference signal to obtain channel estimate information or path parameter information. After obtaining the path parameter information, Sesia discloses that the receiver then provides the path parameter information back to the transmitter as feedback (either explicit or implicit). Ex. 1003 at 662-63; *see e.g., id.* at 271-72.

140. Sesia discloses numerous examples where various types of path parameter information is transmitted to the eNodeB as feedback (either explicitly or implicitly) for subsequent scheduling and transmissions. For example, Sesia discloses that for downlink data transmissions in LTE, the eNodeB typically selects a modulation scheme and code rate depending on the downlink channel conditions. *Id.* at 215. In this example, Sesia discloses that the UE transmits a Channel Quality Indicator (CQI) as feedback to the eNodeB via an uplink, which is then used by the eNodeB for selecting a modulation scheme and/or code rate. *Id.* As another example, Sesia discloses that in the case of transmit beamforming and MIMO precoding, the receiver provides channel estimation information to the eNodeB through a limited feedback link. *Id.* at 263-64. Yet another example, Sesia discloses that the UE may help the eNodeB to derive beamforming precoding weights by sending PMI feedback to the eNodeB. *Id.* at 270-721.

141. As yet another example, Sesia discloses that the scheduling algorithms used by the eNodeB can make use of measurement information such as Channel State Information (CSI) and traffic measures (*e.g.*, volume and priority). *Id.* at 280. Sesia explains that this measurement information can be obtained by either direct measurements performed by the eNodeB or via feedback signaling from the UE. *Id.* at 280-81. As yet another example, Sesia discloses that in some instances, large-scale parameters are fixed, but the channel undergoes fast fading according to the motion of

the UEs. *Id.* at 442. In this example, Sesia explains that the UEs may feedback channel state information about the instantaneous radio channel conditions and the eNodeB can schedule its transmissions accordingly. *Id.*; *see also id.* at 271, 272, 274, 348, 355.

142. Each of these disclosures shows how channel estimation information (*i.e.*, path parameter information) is sent from the receiver to the transmitter after the receiver performs channel estimation to be utilized by the transmitter for subsequent transmissions. Further, Sesia clearly states that the “LTE specifications are designed to provide signaling necessary for the interoperability between the eNodeB and UEs so that the eNodeB can optimize the link adaptation.” *Id.* at 215. As such, a POSITA would understand that the channel estimate information (the path parameter information) is necessarily sent back to the base stations, under the patent owner’s interpretation.

143. Similar to as discussed above with respect to Figures C and D, after obtaining the channel estimate information or path parameter information, when the receiver transmits a signal (*i.e.*, the channel estimate information or path parameter information) to the transmitter, the signal is transmitted back along the propagation path that exists between the transmitter and the receiver.

144. Sesia further discloses the use of a time division duplexing (TDD) scheme which would transmit the uplink signal using the same frequencies and by the same path that the reference signals (the alleged first signal) were received on the

downlink, “by reciprocity” according to the Patent Owners Infringement Contentions. See Ex. 1003 at 147, Figure 6.2; see also Ex. 1007 at 8 (“In at least TDD mode . . . the uplink transmission uses the same propagation path (*via reciprocity*) as the downlink transmission.”) (emphasis added); Ex. 1009 at 8; Ex. 1010 at 8.

145. Accordingly, a POSITA would understand Sesia to disclose that, after obtaining the channel estimate information or path parameter information, the UE transmits a signal, including the channel estimate information to the eNodeB along the propagation path that exists between the transmitter and the receiver. Thus, Sesia discloses and/or renders obvious “sending the channel estimation that includes the path parameter information from the receiver to the transmitter via the first propagation path,” as recited in Claim 1.

These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of sending the channel estimation back to the base station as feedback discloses this limitation.

[1.5] predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain, according to the channel estimation based on the first signal;

146. In my opinion, Sesia discloses and/or renders obvious “predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain, according to the channel estimation based on the first signal” in light of Patent Owner’s apparent interpretation of this limitation based on its infringement contentions

in the related district court proceedings. I have reviewed Mr. Proctor's Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation. As discussed above, Patent Owner seems to interpret "predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain" as broad enough to include beamforming a wireless signal and/or scheduling of transmission resources in the time and frequency domains.

147. As described above in Section VII, and incorporated by reference herein, Sesia discloses multiple methods of beamforming a wireless signal based on path parameter information obtained from reference signals. For example, two such methods of performing beamforming described by Sesia are (i) closed-loop rank-1 precoding and (ii) beamforming with UE-specific reference signals. Ex. 1003 at 270. Sesia also discloses beamforming in a time domain, a frequency domain, and a spatial domain, as well as scheduling of the resources utilized for beamforming in the time and frequency domain.

(i) Beamforming using closed-loop rank-1 precoding according to the channel state information.

148. In closed-loop rank-1 precoding, Sesia explains that the receiver feeds channel state information back to the eNodeB to indicate suitable precoding to apply for beamforming operations. *Id.* The precoding matrix alters the signal so that the

signal is better able to exploit the channel (or path) it is sent along by applying weights that alter the signal in various ways. *Id.* In closed-loop rank-1 precoding, the UE feeds channel state information (known as Precoding Matrix Indicators (PMIs)) back to the base station to indicate what precoding should be applied for beamforming. *Id.* The UE determines the PMIs it reports back to the base station based on channel estimations performed on the reference signals received from the base station. *Id.* at 272-274. This precoding is a form of beamforming. Sesia also explains that the eNodeB is not bound to use any precoder requested by the UE. *Id.* at 273; *see also id.* at 274. Sesia further explains that, in Release 9, the support for MU-MIMO was enhanced to remove the constraint on the eNodeB to use the feedback codebook for precoding and to give flexibility to utilize other approaches to MU-MIMO user separation. *Id.* at 275. Thus, Sesia discloses beamforming a wireless signal based on CSI reported from the UE (*e.g.*, the PMI reported values, as well as the CQI and RI reported values).

(ii) Beamforming with UE-specific reference signals according to the channel state information.

149. Beamforming with UE-specific reference signals functions by utilizing channel state information to alter signals so as to concentrate the base station “power in the directions in which the radio channel offers the strongest path(s) to reach the UE.” *Id.* at 270-271. As such, Sesia discloses beamforming a wireless signal based on CSI reported from the UE.

(iii) Beamforming in a time domain, a frequency domain, and a spatial domain.

150. As discussed above in Section VII, and incorporated herein, Sesia further explains that beamforming using either of these techniques is optimally implemented if the transmitter has full channel knowledge. Ex. 1003 at 249-50, 253291-292. For example, communicating over a MIMO channel, which requires beamforming using full channel knowledge, is one context in which implementing beamforming with full channel knowledge is required for optimality. Ex. 1003 at 253.

151. For example, Sesia discloses that an optimal way of communicating over a MIMO channel involves a channel-dependent precoder, which fulfills the roles of both transmit beamforming and power allocation across the transmitted streams. *Id.* at 253. Sesia explains that this can be achieved if the transmitter has full channel knowledge. *Id.* Sesia explains that this channel knowledge comes from feedback about the propagation path(s) from the receiver based on channel estimation performed on reference signals. *Id.* at 263-264. In particular, Sesia discloses that a UE in LTE “can be configured to report Precoding Matrix Indicators (PMIs) and Rank Indicators (RIs), in addition to CQI [(Channel Quality Indicator)] reporting.” *Id.* at 272. Sesia also explains that explicit feedback (where a UE reports quantized representations of the physical channel state information) could have been used. *Id.* at 663.

152. Furthermore, as explained above, Sesia provides several examples of the types of information that can be determined to help provide the eNodeB with the

full channel knowledge required to beamform signals optimally. Ex. 1003 at 139, 142. For example, with respect to the time-domain, Sesia discloses that the Doppler spread, the carrier frequency, Doppler shift, and the speed of the UE can be determined. Ex. 1003 at 169. As another example, with respect to the frequency-domain, Sesia discloses that channel delay spread and maximum channel delay spread can be determined. *Id.* With respect to the spatial-domain, Sesia discloses that a correlated array of physical antenna elements can be used to generate a narrow beam in the direction of a particular UE. Ex. 1003 at 171. A POSITA would understand that these parameters could be used to assist in beamforming a wireless signal. Furthermore, a POSITA would have a reasonable likelihood of success in doing so. For example, Sesia discloses that explicit feedback was considered in addition to implicit feedback and that the two feedback schemes were found to have similar results, under certain assumptions. Ex. 1003 at 662–63. Thus, Sesia not only discloses “implicit” channel estimations as discussed, but also discloses the potential use of explicit feedback channel estimates as a variation of an LTE based system, and such a system would therefore anticipate, or at the very least render obvious claim element [1.5].

153. Additionally, as discussed above with respect to claim element [1.3], Sesia discloses a transmission model and transfer function that can be used to control how a transmitted signal will be received at the receiver. Sesia’s disclosed model and transfer function includes an impulse response of a channel. As discussed above, the

UE determines the transfer function of channels for different antenna ports based on channel estimations performed on reference signals. *Id.* at 272-74. As such, a POSITA would readily appreciate that a transmitter can similarly determine the channel transfer function and the impulse response of the channel based on the feedback and channel state information provided by the receiver. Generating the impulse response based on the feedback and channel state information provided by the receiver is also consistent with Sesia's statements that in order to estimate the channel as accurately as possible, all correlations between the channel coefficients in time, frequency, and space should be taken into account. *Id.* at 166.

154. A POSITA would thus readily appreciate that an eNodeB can be configured to beamform, which the Patent Owner interprets as "predistort," signals in the frequency-domain, the time-domain, and the spatial-domain based on feedback (*i.e.*, channel state information or path parameter information) that is provided by the receiver.

155. Furthermore, to the extent the Patent Owner is asserting that the scheduling of transmission resources for use with beamforming comprises the predistortion in the time and frequency domains, Sesia discloses the use of a scheduler to select the transmission resources in time and frequency for use with beamforming based upon the fed back channel state information including CQI. In the related district court proceeding, the Patent Owners states in its infringement contentions that "[f]or

example, a 5G NR signal with beamforming is a predistorted signal in time, frequency, and space. For example, applicable time and frequency subcarriers are selected based on the returned CSI, and an appropriate spatial beam refinement is selected based on the returned CSI.” Exhibit 1007 at 9; Ex. 1009 at 9; Ex. 1010 at 9. The Patent Owner further states that “a resource block is placed in a particular subframe (by time) and resource block (by frequency, i.e. subcarriers).” Exhibit 1007 at 10; Ex. 1009 at 10; Ex. 1010 at 10.

156. As I discuss in section VII.A.4 above, Sesia discloses the use of a scheduler to determine “applicable time and frequency subcarriers” which “are selected based on the returned CSI.”

157. “A final important aspect of link adaptation is its use in conjunction with multi-user scheduling in time and frequency, which enables the radio transmission resources to be shared efficiently between users as the channel capacity to individual users varies. The CQI can therefore be used not only to adapt the modulation and coding rate to the channel conditions, but also for the optimization of time/frequency selective scheduling and for intercell interference management.” Ex. 1003 at 216. The CQI reporting by the UE may be configured to report the channel quality in different portions of the channel. For example, Sesia teaches “[t]he UE reports a wideband CQI value for the whole system bandwidth. In addition, the UE reports a CQI value for each sub-band, calculated assuming transmission only in the relevant sub-band.” *Id.* at 221.

Furthermore, PMI may be reported for both wideband (the entire channel) and for sub-band frequencies of the channels. *Id.* at 273.

158. Because the CSI information (including CQI) is utilized in the scheduler, and CQI is affected by the choice of precoder (*e.g.*, beamforming), the beamforming benefit effects the scheduling of the resources. “The eNodeB has to adjust the MCS used for transmission relative to the CQI reports by estimating the expected beamforming gain depending on the number of transmitted layers.” Ex. 1003 at 272. The Modulation and Coding Scheme (MCS) determines the number of resources required to be scheduled to carry the transmission block(s). *Id.* at 217-19. Thus, the reported rank indicator (RI) is utilized to determine the number of layers (transmission blocks) to be scheduled, and the PMI is utilized to determine the beamformer’s CQI benefit associated with a particular resource in time and frequency when scheduling as discussed above.

159. As such, a POSITA would understand Sesia to disclose transmitting a signal on applicable time and frequency subcarriers based on CSI, and an appropriate spatial beam refinement based on CSI, which according to the Patent Owner, in the related district court proceedings, meets this limitation. Thus, Sesia discloses and/or renders obvious “predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain, according to the channel estimation based on

the first signal,” as recited in Claim 1 under Patent Owner's apparent interpretation of the claims which is broad enough to capture beamforming a wireless signal.

These explanations, which I have adopted from Mr. Proctor's Declaration, reflect my own opinion that Sesia's description of beamforming discloses this limitation.

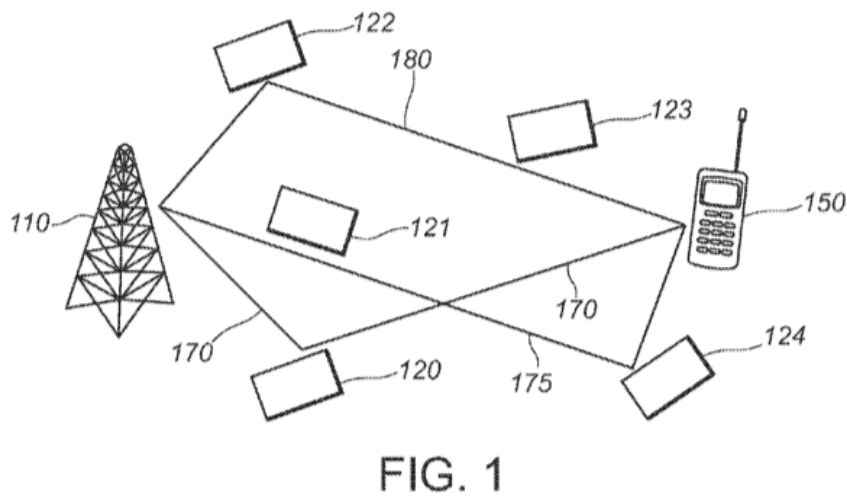
[1.6] transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path; and

160. In my opinion, Sesia discloses and/or renders obvious “transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path.” I have reviewed Mr. Proctor's Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

161. I incorporate the discussion provided above with respect to claim elements **[1.4]** and **[1.5]** of Claim 1.

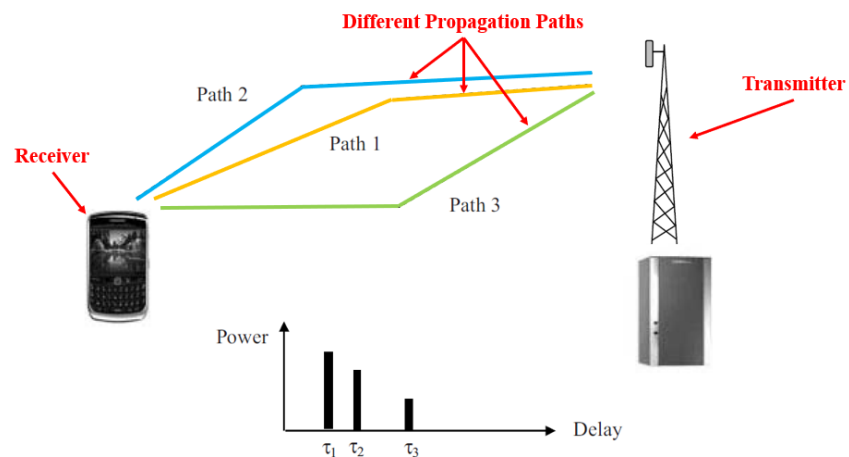
162. As discussed above with respect to Figures C and D, when the transmitter transmits a signal (*e.g.*, the predistorted second signal) to the receiver, the signal is transmitted along at least one, if not all of a plurality of propagation paths (*i.e.*, including at least the first propagation path) that exist between the transmitter and the receiver. For example, Fig. 1 of the '347 depicts multiple paths 180, 170, and 175 from the transmitter 110 to the receiver 150. Ex. 1001 at 3:28-30.

Figure A – Fig. 1 of '347 Patent



163. Likewise, Sesia in Figure 20.1 depicts similar propagation paths from a transmitter to a receiver as follows:

Figure C – Annotated Figure 20.1 of Sesia (Ex. 1003)



164. In this case, the predistorted second signal is transmitted by the transmitter to the receiver along at least one of the same propagation paths that exists

between the transmitter and the receiver, on which the receiver previously performed channel estimation. As discussed in association with element [1.2], the first signal (the reference signal) is received from the transmitter using at least one of the plurality of propagation paths. Sesia discloses, and a POSITA would consider it obvious that the first signal (the reference signal) can be received as a “multipath” signal via each (*i.e.*, all) of the plurality of paths as depicted in Figure C, which would necessarily include the claimed first propagation path. Given the predistorted signal is received at the receiver, it must follow at least one of the plurality of propagation paths between the transmitter and the receiver, or else it could not be received. In this example, the predistorted second signal is transmitted to the receiver via at least one of the propagation paths (*i.e.*, the first propagation path) of the set of propagation paths used for the transmission of the first signal (*e.g.*, all the propagation paths). Thus, it would be obvious in this example that the predistorted signal will follow at least the claimed first propagation path utilized by the first signal.

165. Furthermore, it would have been obvious to a POSITA that the “predistorted second signal” is transmitted from the transmitter to the receiver via the same “first propagation path,” Given that one of the purposes of beamforming is to maximize a given UE’s signal reception by steering the transmission beam in the direction of a given UE, which would necessarily include the “first propagation path” to the extent it is the best path to select or otherwise optimize. In addition, as explained

above for element [1.5], measuring the path parameters of a given path and reporting said parameters to the base station is one method that can be used to perform beamforming. As such, a POSITA would understand that the beamformed signals would traverse along the same “first” propagation path. If the beamformed signals did not do so, then the initial channel estimates would no longer be reflective of the propagation path, and the beamforming likely wouldn’t effective.

166. Thus, Sesia discloses and/or renders obvious “transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path,” as recited in Claim 1. These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of transmitting beamformed signals discloses this limitation.

[1.7] receiving the predistorted second signal at the receiver.

167. In my opinion, Sesia discloses and/or renders obvious “receiving the predistorted second signal at the receiver.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

168. I incorporate the discussion provided above with respect to claim elements [1.2], [1.4], and [1.5] of Claim 1.

169. As discussed above with respect to Figures C and D, the receiver will receive the predistorted second signal transmitted by the transmitter on the propagation path (*i.e.*, the first propagation path) that exist between the transmitter and the receiver. In this case, the receiver receives the predistorted second signal that is transmitted by the transmitter via the propagation path that exist between the transmitter and the receiver.

170. Thus, Sesia discloses and/or renders obvious “receiving the predistorted second signal at the receiver,” as recited in Claim 1. These explanations, which I have taken from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of transmitting beamformed signals discloses this limitation.

B. Dependent Claim 2

171. Claim 2 depends from Claim 1, and thus the discussion above with respect to Claim 1 is incorporated by reference. In my opinion, Sesia also discloses and/or renders obvious the additional limitation of Claim 2: “wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own

opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

172. As discussed above with respect to claim element **[1.3]**, Sesia discloses that channel estimations are made to obtain path parameter information of the first propagation path and can include information related to the frequency-domain, the time-domain, and the spatial-domain. Ex. 1003 at 166.

173. In addition, Sesia also explicitly discloses each of the claim elements recited in Claim 2. For example, with respect to “an estimation of a delay,” Sesia discloses that as a part of channel estimation phase shifts can be recovered. *Id.* at 135-36. Sesia further explains that a phase shift corresponds with a time delay spread in the time-domain. *Id.* As another example, Sesia explains that “expected delay spread” is one of the main propagation characteristics which should be taken into account. *Id.* at 139; *see also id.* at 142. As such, based on these disclosure of Sesia, a POSITA would understand that Sesia’s expected delay spread corresponds with the claimed “estimation of delay.”

174. As another example, with respect to “an estimation of a Doppler frequency,” Sesia discloses “Doppler frequency” is also one of the main propagation characteristics which should be taken into account. *Id.* at 139; *see also id.* at 142. Sesia explains that the frequency error due to Doppler based on the relative speed between the transmitter and the receiver can be determined by the channel estimation process.

Id. at 136. Sesia also discloses that the Doppler spread can be used to determine the spacings between symbols in the frequency-domain. *Id.* at 169. As such, based on the disclosure of Sesia, a POSITA would understand that Sesia's Doppler frequency corresponds with the claimed "estimation of a Doppler frequency."

175. As a further example, with respect to "an estimation of a direction of arrival," Sesia discloses that information such as Direction of Arrival (DOA) estimations can be used by an eNodeB for beamforming operations. *Id.* at 271. Sesia also discloses that spatial characteristics of a MIMO channel are defined Angular Spread (AS) and the directional distribution of the propagation paths at both the eNodeB and the UE. *Id.* at 442. As shown in Figure I, Figure 20.2 of Sesia illustrates the spatial parameters that are considered by Sesia, which includes Angle of Arrival (AoA) which corresponds with a Direction of Arrival. *Id.* at 443; *see also id.* at Table 20.4; *id.* at 445, 447, 450. As such, based on the disclosure of Sesia, a POSITA would understand that Sesia's Direction of Arrival and Angle of Arrival correspond with the claimed "estimation of a direction of arrival."

Figure I – Figure 20.2 of Sesia (Ex. 1003)

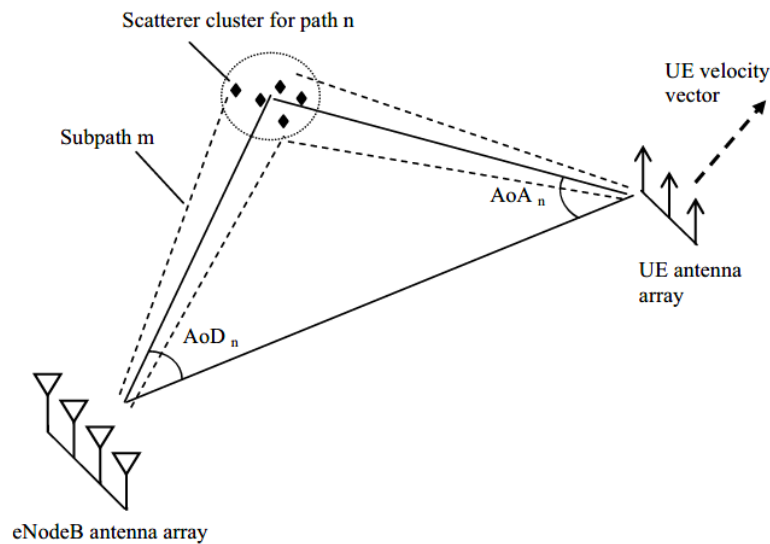


Figure 20.2: Geometry for generating spatial parameters for base station and UE.

176. As another example, with respect to “an estimation of a direction of departure,” as shown above in Figure I, Figure 20.2 of Sesia illustrates the spatial parameters that are considered by Sesia, which includes Angle of Departure (AoD) which corresponds with a Direction of Departure. *Id.* at 443, 445, 447, 450; *see also id.* at Table 20.4. Thus, based on the disclosure of Sesia, a POSITA would understand that Sesia’s Angle of Departure corresponds with the claimed “estimation of a direction of departure.”

177. As another example, with respect to “an estimation of a complex amplitude of the first propagation path,” Sesia discloses a process for determining amplitude imbalances which can vary based on frequency as a result of a timing offset

between in-phase and quadrature signal paths. *Id.* at 496-97. During this discussion, Sesia provides several equations (*e.g.*, Equations 21.9, 21.10, 21.11, and 21.12) that include complex amplitude estimates and weights, which are generally represented mathematically in the form of $Ae^{j\varphi}$. *Id.* Sesia also discloses that some link control methods make use of amplitude information from the channel. *Id.* at 559; *see also id.* at 560 and 561. Based on the disclosure of Sesia, a POSITA would understand that Sesia's examples of complex amplitude estimates and weights correspond with the claimed "estimation of a complex amplitude of the first propagation path."

178. Thus, Sesia discloses and/or renders obvious "wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path," as recited in Claim 2. These explanations, which I have adopted from Mr. Proctor's Declaration, reflect my own opinion that Sesia's description of channel estimation discloses this limitation.

C. Dependent Claim 3

179. Claim 3 depends from Claim 2 which depends from Claim 1, and thus the discussions above with respect to Claim 1 and Claim 2 are incorporated by reference. In my opinion, Sesia also discloses and/or renders obvious the additional limitation of Claim 3: "wherein the path parameter information of the first propagation

path further includes an estimation of a polarization status of the first propagation path.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

180. Sesia discloses that cross-polarized or orthogonally-polarized antennas can be utilized in both eNodeBs and the UEs. Ex. 1003 at 446. As shown in Figures J and K, Figures 20.3 and 20.4 of Sesia illustrate examples of antenna configurations for an eNodeB and UE, respectively. *Id.* at 447. Sesia discloses that spatial correlations of an LTE performance evaluation model can be determined based on antenna characteristics and the path arrival/departure angles. *Id.* at 447. Sesia further discloses that polarization covariance matrices can be determined based on the antenna polarizations. *Id.*

Figure J – Figure 20.3 of Sesia (Ex. 1003)

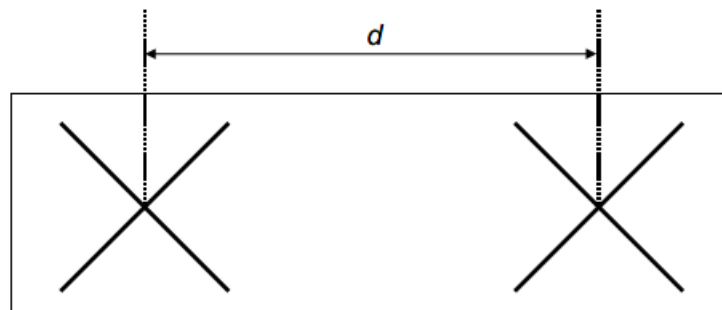


Figure 20.3: Base station antenna configuration.

Figure K – Figure 20.4 of Sesia (Ex. 1003)

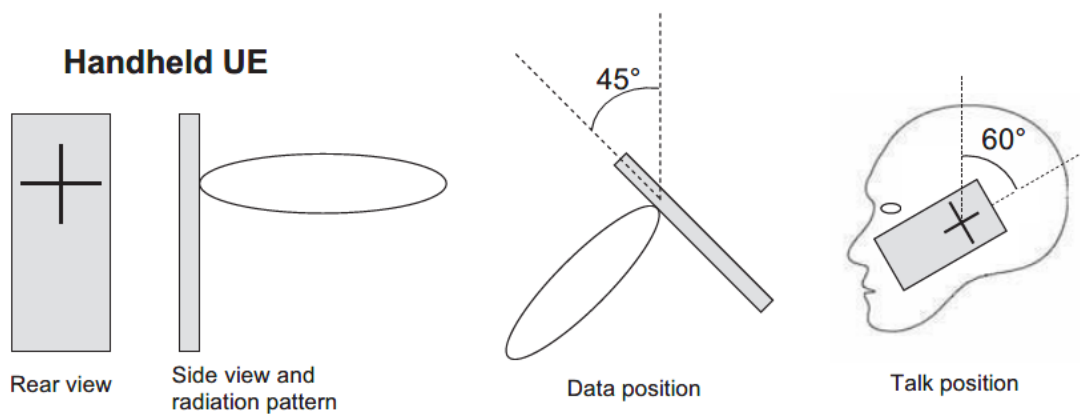


Figure 20.4: Handset antenna configuration.

181. Sesia explains that the relatively persistent nature of spatial signatures of subarrays facilitates robust MU-MIMO scheduling with predictable multi-user interference. *Id.* at 663. However, Sesia further explains that a low correlation between the cross-polarized subarrays yields improved diversity for SU-MIMO scheduling. *Id.*; *see also id.* at 264.

182. Table 29.3 of Sesia, shown below, illustrates an example of how polarization information can be used in conjunction with the feedback that is provided to the eNodeB. Here, Sesia explains that cross-polarized dimensions (corresponding to low correlation) are combined with co-phasing factors represented by quaternary symbols. *Id.* at 663-64.

Figure L - Table 29.3 of Sesia (Ex. 1003)

Table 29.3: PMI feedback codebook design for the case of 2-layer feedback with 8 CSI-RS antenna ports.

i_2	0	1	2	3
Codebook	$W_{2i_1,2i_1,0}$	$W_{2i_1,2i_1,1}$	$W_{2i_1+1,2i_1+1,0}$	$W_{2i_1+1,2i_1+1,1}$
i_2	4	5	6	7
Codebook	$W_{2i_1+2,2i_1+2,0}$	$W_{2i_1+2,2i_1+2,1}$	$W_{2i_1+3,2i_1+3,0}$	$W_{2i_1+3,2i_1+3,1}$
i_2	8	9	10	11
Codebook	$W_{2i_1,2i_1+1,0}$	$W_{2i_1,2i_1+1,1}$	$W_{2i_1+1,2i_1+2,0}$	$W_{2i_1+1,2i_1+2,1}$
i_2	12	13	14	15
Codebook	$W_{2i_1,2i_1+3,0}$	$W_{2i_1,2i_1+3,1}$	$W_{2i_1+1,2i_1+3,0}$	$W_{2i_1+1,2i_1+3,1}$

$$W_{m,k,n} = \frac{1}{4} \begin{bmatrix} \mathbf{v}_m & \mathbf{v}_k \\ e^{j\pi n/2} \mathbf{v}_m & -e^{j\pi n/2} \mathbf{v}_k \end{bmatrix}, \quad \mathbf{v}_m = \begin{bmatrix} 1 & e^{j2\pi m/32} & e^{j4\pi m/32} & e^{j6\pi m/32} \end{bmatrix}^T.$$

The index $0 \leq i_1 \leq 15$ selects a cluster of beams from a set of partially overlapping clusters in a co-polarized subarray. The LSB of the index $0 \leq i_2 \leq 15$ selects one of the two co-phasing factors while the 3 MSBs of i_2 select one of 8 pairs of beams within a cluster.

183. Based on the disclosure of Sesia, a POSITA would readily appreciate that Sesia’s channel estimation process and channel estimation information feedback may consider and include polarization information (*e.g.*, polarization status) for cross-polarized or orthogonally-polarized antennas.

184. Thus, Sesia discloses and/or renders obvious “wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path,” as recited in Claim 3. These

explanations, which I have adopted from Mr. Proctor's Declaration, reflect my own opinion that Sesia's description of channel estimation discloses this limitation.

D. Dependent Claim 4

185. Claim 4 depends from Claim 1, and thus the discussion above with respect to Claim 1 is incorporated by reference. In my opinion, Sesia also discloses and/or renders obvious the additional limitation of Claim 4: "wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum-likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation- maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least- square-error methods." I have reviewed Mr. Proctor's Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

186. I incorporate the discussion provided above with respect to Claim 2.

187. Further, Sesia discloses multiple techniques and algorithms that can be used for performing channel estimation. A POSITA would readily appreciate that Sesia discloses numerous techniques and parameters that correspond with the techniques and parameters recited in Claim 4. For example, Sesia discloses the following techniques:

- Linear interpolation (Ex. 1003 at 178)
- Bayesian techniques (*Id.*)
- Least-Squares (LS) error methods (*Id.* at 179)
- Regularized LS error methods (*Id.*)
- Minimum mean-squared error (MMSE) (*Id.*)
- Mismatched MMSE (*Id.*)
- Simple interpolator (*Id.* at 180)
- Fast Fourier Transformation (FFT) (*Id.*)
- Inverse Fast Fourier Transform (IFFT) (*Id.* at 180-81)
- Spectral-based methods (*Id.* at 181-82)
- Time-domain MMSE (*Id.* at 185)
- Normalized Least-Mean-Squares (NLMS) (*Id.*)
- Kalman filtering techniques (*Id.*)
- Maximum-likelihood estimation (*Id.* at 225)
- Maximum-a-posteriori based methods (*Id.*)

188. As one specific example, Claim 4 requires the use of “at least one estimation technique of the group consisting of a maximum-likelihood estimation algorithm” Sesia explicitly discloses channel estimation based upon of a maximum-likelihood approach: “[i]n the LTE context, as for any OFDM system with uniformly distributed reference symbols [18], the Channel Transfer Function (CTF) can be estimated using **a maximum likelihood approach** in the frequency domain.” Ex. 1003 at 178 (emphasis added).

189. In addition, as noted by the '347 Patent, the estimation techniques recited in Claim 4 are well-known and commonly used techniques for performing channel estimation. Ex. 1001 at 8:17-67. As such, a POSITA would have known that any of the methods identified in Claim 4 could be used for channel estimation and would have yielded predictable results.

190. Thus, Sesia discloses and/or renders obvious “wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum-likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation- maximization), RiMAX (Richter's

Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods,” as recited in Claim 4. These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of the multiple techniques for performing channel estimation discloses this limitation.

E. Dependent Claim 6

191. Claim 6 depends from Claim 1, and thus the discussion above with respect to Claim 1 is incorporated by reference. In my opinion, Sesia also discloses and/or renders obvious the additional limitation of Claim 6: “equalizing the predistorted second signal at the receiver.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

192. As shown in Figures M and N, annotated Figures 21.2 and 21.3 of Sesia illustrate some of the operations and functions that are performed at the receiver, which includes an equalizer for performing equalization on received signals. Ex. 1003 at 463 and 464.

Figure M – Annotated Figure 21.2 of Sesia (Ex. 1003)

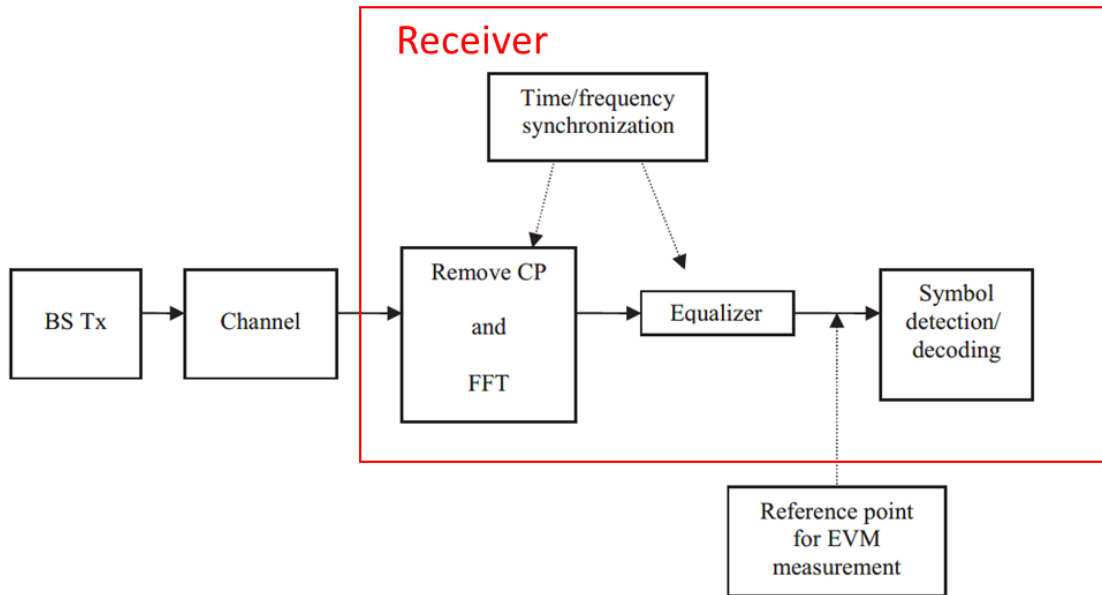


Figure 21.2: Measurement points for the EVM for the downlink signal.

Figure N – Annotated Figure 21.3 of Sesia (Ex. 1003)

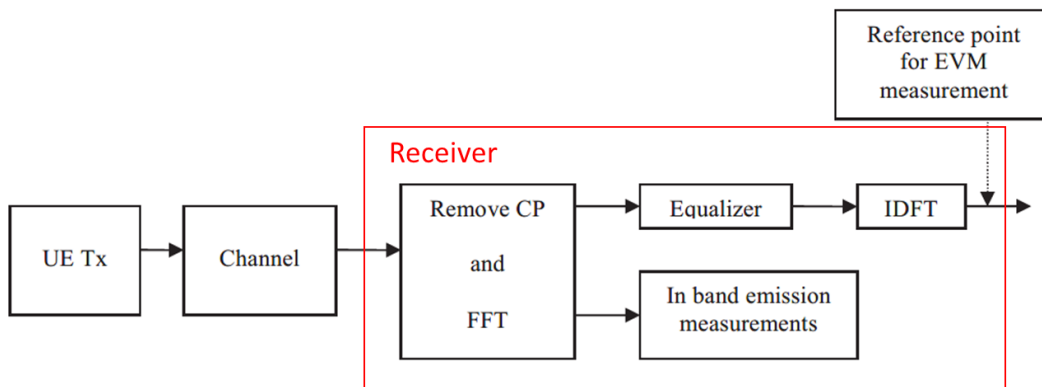


Figure 21.3: Measurement points for the EVM for the uplink signal.

193. Sesia further discloses that many different types of equalization algorithms can be used by a receiver to remove noise (*e.g.*, Inter-Symbol Interference (ISI)) that impacts a transmitted signal as it travels through a radio channel. *Id.* at 165. For example, Sesia discloses performing frequency-domain equalization at the receiver. *Id.* at 15. As another example, Sesia discloses performing equalization at the receiver to recover OFDM symbols. *Id.* at 128. Based on the disclosures of Sesia, a POSITA would readily appreciate that Sesia discloses performing equalization at the receiver.

194. Thus, Sesia discloses and/or renders obvious “equalizing the predistorted second signal at the receiver,” as recited in Claim 6. These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of an equalizer discloses this limitation.

F. Dependent Claim 7

195. Claim 7 depends from Claim 6 which depends from Claim 1, and thus the discussions above with respect to Claim 1 and Claim 6 are incorporated by reference. In my opinion, Sesia also discloses and/or renders obvious the additional limitation of Claim 7: “wherein equalizing the predistorted second signal is performed using a joint processing technique in a coordinated multiple-point (CoMP) system.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after

reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

196. Sesia discloses that coordinated multiple-point (CoMP) systems are well known in the art prior to the effective filing date of the '347 Patent. For example, Sesia discloses that CoMP transmission and reception, also known as Cooperative MIMO, has received significant attention in academic literature and is being studied as a technique to increase performance within the evolution of LTE-Advanced for Release 11 or beyond. Ex. 1003 at 669; *see also id.* at 670-71. Furthermore, I note that the '347 Patent itself identifies CoMP systems in the background section of the '347 Patent. *See* Ex. 1001 at 1:11-21.

197. Sesia discloses that, in a multicell context, neighboring base stations sharing their antennas in virtual MIMO fashion to communicate with the same set of UEs in different cells is referred to as CoMP transmission and reception. Ex. 1003 at 250-252. As shown below in Figure O, Figure 11.1 of Sesia illustrates the evolution of MIMO concepts from the simplest diversity setup to the advanced joint-processing CoMP technique (shown as Cooperative Multicell MU-MIMO). *Id.*

Figure O – Figure 11.1 of Sesia (Ex. 1003)

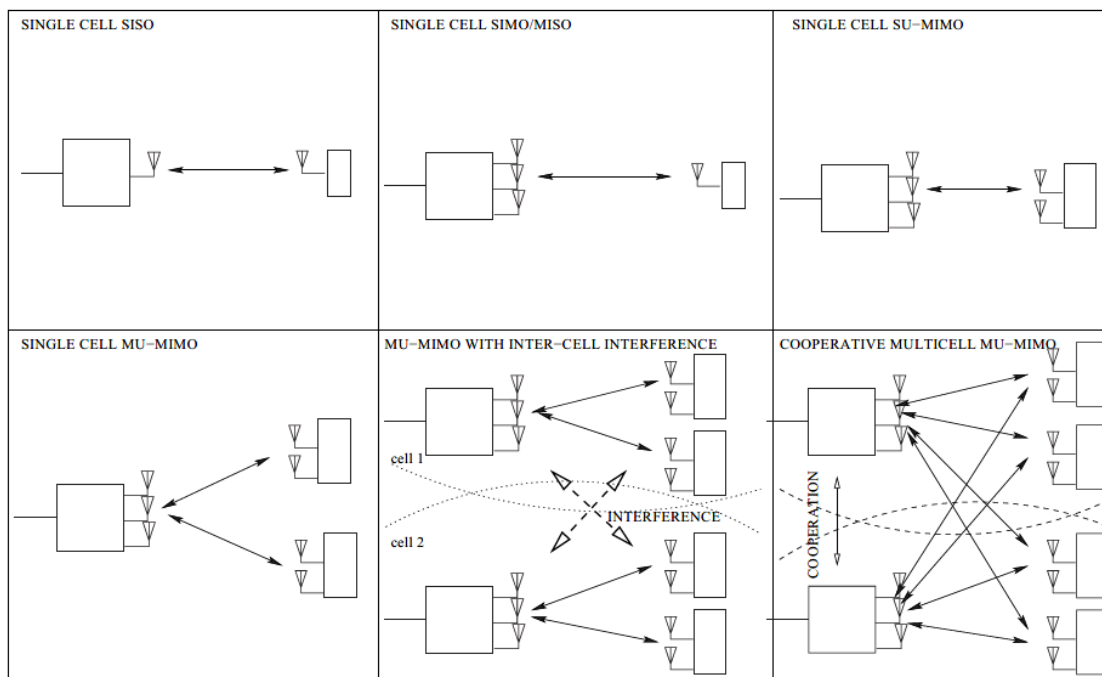


Figure 11.1: The evolution of MIMO technology, from traditional single antenna communication, to multi-user MIMO scenarios, to the possible multicell MIMO networks of the future.

198. Sesia further discloses that in order to further improve spectral efficiency, especially at the cell edge, a later release of LTE-Advanced may incorporate enhanced support for CoMP schemes. *Id.* at 619. Sesia explains that CoMP transmissions in the downlink entails the coordination of transmissions from multiple cells. *Id.* Sesia further explains that this coordination may include techniques such as coordinated scheduling to one or more UEs or multisite beamforming approaches. *Id.* Sesia also states that as part of the network implementation of LTE Release 8, in the uplink, CoMP reception at different cells is already possible. *Id.* Based on the

disclosures of Sesia, a POSITA would readily appreciate that CoMP systems and joint processing techniques in CoMP systems were well known in the art.

199. Thus, Sesia discloses and/or renders obvious “wherein equalizing the predistorted second signal is performed using a joint processing technique in a coordinated multiple-point (CoMP) system,” as recited in Claim 7. These explanations, which I have taken from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of cooperative MIMO discloses this limitation.

G. Independent Claim 8

[8.0] A system for wireless communication comprising:

200. Sesia discloses a “system for wireless communication.”

201. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[8.1] a receiver;

202. Sesia discloses and/or renders obvious “a receiver.”

203. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[8.2] a transmitter; and

204. Sesia discloses and/or renders obvious “a transmitter.”

205. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[8.3] a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver,

206. Sesia discloses and/or renders obvious “a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver.”

207. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[8.4] wherein the receiver is configured to receive a first signal that is transmitted along a first propagation path of the plurality of propagation paths from the transmitter, perform a channel estimation based on the first signal to obtain path parameter information of the first propagation path, and send the channel estimation that includes the path parameter information to the transmitter via the first propagation path, and

208. Sesia discloses and/or renders obvious “the receiver is configured to receive a first signal that is transmitted along a first propagation path of the plurality of propagation paths from the transmitter, perform a channel estimation based on the first signal to obtain path parameter information of the first propagation path, and send the channel estimation that includes the path parameter information to the transmitter via the first propagation path.”

209. I incorporate the discussion provided above with respect to claim elements **[1.1]**, **[1.2]**, **[1.3]**, and **[1.4]** of Claim 1.

[8.5] wherein the transmitter is configured to predistort a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation that is based on the first signal and received from the

receiver and to transmit the predistorted second signal to the receiver via the first propagation path.

210. Sesia discloses and/or renders obvious “the transmitter is configured to predistort a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation that is based on the first signal and received from the receiver and to transmit the predistorted second signal to the receiver via the first propagation path.”

211. I incorporate the discussion provided above with respect to claim elements [1.5], [1.6], and [1.7] of Claim 1.

H. Dependent Claim 9

212. Claim 9 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.”

213. I incorporate the discussion provided above with respect to Claim 2.

I. Dependent Claim 10

214. Claim 10 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Sesia discloses and/or renders obvious

“wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.”

215. I incorporate the discussion provided above with respect to Claim 3.

J. Dependent Claim 11

216. Claim 11 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least square-error methods.”

217. I incorporate the discussion provided above with respect to Claim 4.

K. Dependent Claim 12

218. Claim 12 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. In my opinion, Sesia also discloses and/or renders obvious the additional limitation of Claim 12: “wherein the transmitter and the receiver each comprise multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

219. Sesia provides numerous disclosures relating to using SISO and MIMO in wireless communications. Ex. 1003 at 249-52. For example, Sesia discloses how SISO is used in traditional wireless communications and that the presence of multiple antennas in MIMO enables devices to leverage the spatial-domain for improved performance. *Id.* Furthermore, as shown above in Figure O, Figure 11.1 of Sesia illustrates numerous antenna configurations which includes SISO and MIMO antenna configurations. *Id.* at 251, Fig. 11.1. As such, it would be evident to a POSITA from Sesia’s disclosures that the use of SISO and MIMO in wireless communications were well known in the art before the effective filing date of the ’347 Patent.

220. Thus, Sesia discloses and/or renders obvious “wherein the transmitter and the receiver each comprise multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system,” as recited in Claim 12. These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of SISO and MIMO discloses this limitation.

L. Dependent Claim 14

221. Claim 14 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the receiver is further configured to equalize the predistorted second signal.”

222. I incorporate the discussion provided above with respect to Claim 6.

M. Independent Claim 15

[15.0] A base station for performing wireless communication with a receiver in a wireless device via a plurality of propagation paths, the base station comprising:

223. In my opinion, Sesia discloses and/or renders obvious “[a] base station for performing wireless communication with a receiver in a wireless device via a plurality of propagation paths.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

224. I incorporate the discussion provided above with respect to claim element [1.0] of Claim 1.

225. Furthermore, Sesia discloses that the core network in LTE is comprised of base stations known as NodeBs or evolved NodeBs (eNodeBs), which connect to UEs. *Id.* at 26; *see also id.* at xxxv and xxxii. Based on the disclosure of Sesia, it is noted that a POSITA would understand that the terms “base station,” “NodeB,” and “eNodeB” can all be used interchangeably in Sesia. An example of this configuration is shown below in Figure P.

Figure P – Figure 2.1 of Sesia (Ex. 1003)

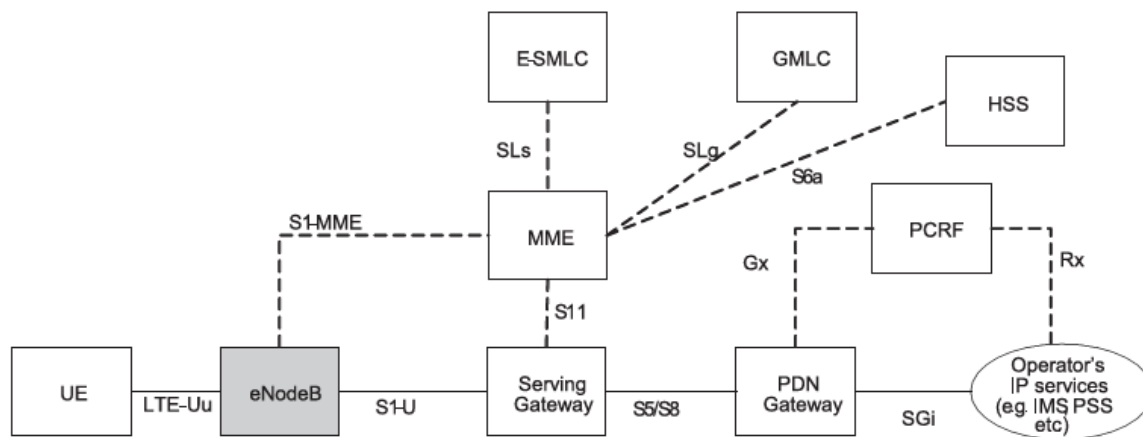


Figure 2.1: The EPS network elements.

226. Thus, Sesia discloses and/or renders obvious “[a] base station for performing wireless communication with a receiver in a wireless device via a plurality of propagation paths,” as recited in claim element [15.0]. These explanations, which I

have adopted from Mr. Proctor's Declaration, reflect my own opinion that Sesia's description of eNodeB base stations discloses this limitation.

[15.1] a transmitter;

227. Sesia discloses and/or renders obvious "a transmitter."

228. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[15.2] a computing device; and

229. In my opinion, Sesia discloses and/or renders obvious "a computing device." I have reviewed Mr. Proctor's Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

230. For example, Sesia discloses that a transmitter (*e.g.*, an eNodeB or UE) utilizes microprocessors for handling and processing the data (*e.g.*, Service Data Units (SDUs) and Protocol Data Units (PDUs)) that is sent to a receiver device. *Id.* at 88. Sesia also discloses how the increase in processing power of modern Digital Signal Processors (DSPs) of eNodeBs has paved the way for OFDM usage in LTE. *Id.* at 124. Based on Sesia's discloses, it is clear that the transmitter is a computing device that includes one or more microprocessors and/or DSPs for performing various operations and processing data.

231. Thus, Sesia discloses and/or renders obvious “a computing device,” as recited in claim element [15.2]. These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of eNodeB processors discloses this limitation.

[15.3] a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations comprising:

232. In my opinion, Sesia discloses and/or renders obvious “a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

233. For example, Sesia provides multiple explanation of how memories (*i.e.*, computer-readable storage mediums) are used in performing various wireless communications operations. For example, Sesia discloses the usage of processors and memories and their requirement for channel coding of data channels in LTE. *Id.* at 232-33. As another example, Sesia discloses memory and its role when performing channel estimations. *Id.* at 181. As yet another example, Sesia also discloses the role of using memory for various coding techniques such as Turbo coding, Contention-Free Turbo Coding, and Low-Density Parity-Check (LDPC) coding. *Id.* at 233-36.

234. Further, a POSITA would readily appreciate that the usage of computer-readable storage mediums (*i.e.*, memories) to store executable instructions for processors (*e.g.*, microprocessors or DSPs) is well-known in electrical arts prior to the effective filing date of the '347 Patent.

235. Thus, Sesia discloses and/or renders obvious “a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations,” as recited in claim element [15.3]. These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of memory discloses this limitation.

[15.3.1] transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths;

236. Sesia discloses and/or renders obvious “transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths.”

237. I incorporate the discussion provided above with respect to claim element [1.1] of Claim 1.

[15.3.2] receiving a channel estimation based on the first signal, the channel estimation including path parameter information of the first propagation path;

238. Sesia discloses and/or renders obvious “receiving a channel estimation based on the first signal, the channel estimation including path parameter information of the first propagation path.”

239. I incorporate the discussion provided above with respect to claim elements [1.2], [1.3], and [1.4] of Claim 1.

[15.3.3] predistorting a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal; and

240. Sesia discloses and/or renders obvious “predistorting a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.”

241. I incorporate the discussion provided above with respect to [1.5] of Claim 1.

[15.3.4] transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path.

242. Sesia discloses and/or renders obvious “transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path.”

243. I incorporate the discussion provided above with respect to claim element [1.6] of Claim 1.

N. Dependent Claim 16

244. Claim 16 depends from Claim 15, and thus the discussion above with respect to Claim 15 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, an estimation of a

complex amplitude of the first propagation path, and an estimation of a polarization status of the first propagation path.”

245. I incorporate the discussion provided above with respect to Claim 2.

O. Dependent Claim 17

246. Claim 17 depends from Claim 15, and thus the discussion above with respect to Claim 15 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the transmitter comprises multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.”

247. I incorporate the discussion provided above with respect to Claim 12.

P. Independent Claim 19

[19.0] A wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths, the wireless device comprising:

248. In my opinion, Sesia discloses and/or renders obvious “[a] wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths.” I have reviewed Mr. Proctor’s Declaration with respect to this limitation, and after reviewing the evidence and forming my own opinions, I find his explanation is consistent with my own opinions, so I have adopted his explanation.

249. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1 and Claim 6.

250. As shown above in Figure N, Sesia discloses that, in LTE, wireless devices that communicate with eNodeBs in a network are known as UEs. *Id.* at 26; *see also id.* at 17-18.

251. Thus, Sesia discloses and/or renders obvious “[a] wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths,” as recited in claim element [19]. These explanations, which I have adopted from Mr. Proctor’s Declaration, reflect my own opinion that Sesia’s description of wireless devices discloses this limitation.

[19.1] a receiver;

252. Sesia discloses and/or renders obvious “a receiver.”

253. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[19.2] a computing device; and

254. Sesia discloses and/or renders obvious “a computing device.”

255. I incorporate the discussion provided above with respect to claim element **[15.2]** of Claim 15.

[19.3] a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations comprising:

256. Sesia discloses and/or renders obvious “a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations.”

257. I incorporate the discussion provided above with respect to claim element **[15.3]** of Claim 15.

[19.3.1] receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths;

258. Sesia discloses and/or renders obvious “receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths.”

259. I incorporate the discussion provided above with respect to claim elements **[1.1]** and **[1.2]** of Claim 1.

[19.3.2] performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path;

260. Sesia discloses and/or renders obvious “performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path.”

261. I incorporate the discussion provided above with respect to claim element **[1.3]** of Claim 1.

[19.3.3] sending the channel estimation that includes the path parameter information to the transmitter; and

262. Sesia discloses and/or renders obvious “sending the channel estimation that includes the path parameter information to the transmitter.”

263. I incorporate the discussion provided above with respect to claim element **[1.4]** of Claim 1.

[19.3.4] receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.

264. Sesia discloses and/or renders obvious “receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.”

265. I incorporate the discussion provided above with respect to claim elements **[1.5]**, **[1.6]**, and **[1.7]** of Claim 1.

Q. Dependent Claim 20

266. Claim 20 depends from Claim 19, and thus the discussion above with respect to Claim 19 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.”

267. I incorporate the discussion provided above with respect to Claim 2.

R. Dependent Claim 21

268. Claim 21 depends from Claim 20 which depends from Claim 19, and thus the discussions above with respect to Claim 19 and Claim 20 are incorporated by reference. Sesia discloses and/or renders obvious “wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.”

269. I incorporate the discussion provided above with respect to Claim 3.

S. Dependent Claim 22

270. Claim 22 depends from Claim 19, and thus the discussion above with respect to Claim 19 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT(Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation- maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques,

enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.”

271. I incorporate the discussion provided above with respect to Claim 4.

T. Dependent Claim 23

272. Claim 23 depends from Claim 19, and thus the discussion above with respect to Claim 19 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the receiver comprises multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.”

273. I incorporate the discussion provided above with respect to Claim 12.

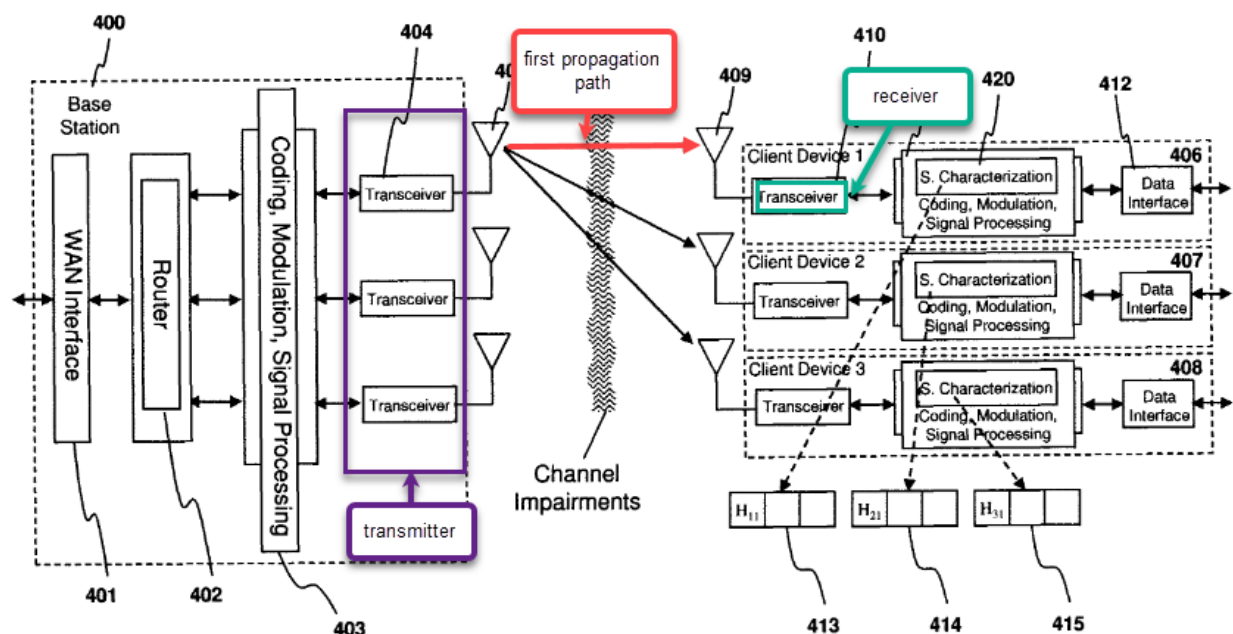
IX. GROUND 2: FORENZA RENDERS OBVIOUS CLAIMS 1-4, 6-12, 14-17, AND 19-23

A. Summary of Forenza

274. Forenza discloses a similar system where multiple antennas of a base station “work cooperatively to pre-cancel interference and create parallel non-interfering data streams to multiple users.” Ex. 1014, 10:26-29. In this embodiment, a base station “is provisioned with a number (N) of antennas” which serve “a number of Client Devices 203-207, each with a single antenna,” although the embodiment also works with MIMO systems. Ex. 1014, 28:15-26. Forenza describes its system as a MIDO (multiple-in, distributed-out) or DIDO (distributed-in, distributed-out) system.

Figures 4-6 of Forenza teach how the multi-antenna system transmits data to client devices.

275. Forenza describes that in Figure 4, “before a MIMO transmission begins, the channel is characterized.” Ex. 1014, 31:4-5. This is done by transmitting a “training signal ..., one-by-one, by each of the antennas 405” of the multi-antenna base station. *Id.*, 31:6-7. Figure 4 “illustrates only the first training signal transmission, but with three antennas 405 there are three separate [training] transmissions in total.” *Id.*, 31:8-10.



Antenna 1 Pilot Signal Transmission

Fig. 4

276. Each client device receives a training signal from each antenna of the transmitter. *Id.*, 31:18-20. The “[s]ignal characterization logic 320” at each client device “characterizes the resulting signal (e.g., identifying phase and amplitude

distortions ...) and stores the characterization in memory,” *i.e.* memory 413, 414, and 415. *Id.*, 31:23-26. The characterizations are stored as vectors labeled as H_{nm} , where n is the client device and m is the propagation path, with each client device storing “a 1x3 row 413-415 of the H matrix.” *Id.*, 31:60-62. The characterizations can also include channel state information. *Id.*, 15:4-18.

277. As show in Figure 5, “after all three pilot transmissions are complete, each Client Device 506-508 transmits back to the Base Station 500 the 1x3 row 513-515 of matrix H that it has stored.” *Id.*, 32:7-10. As the base station “receives the 1x3 row 513-515, from each Client Device 507-508, it stores it in a 3x3 H matrix 516.” *Id.*, 32:27-30.

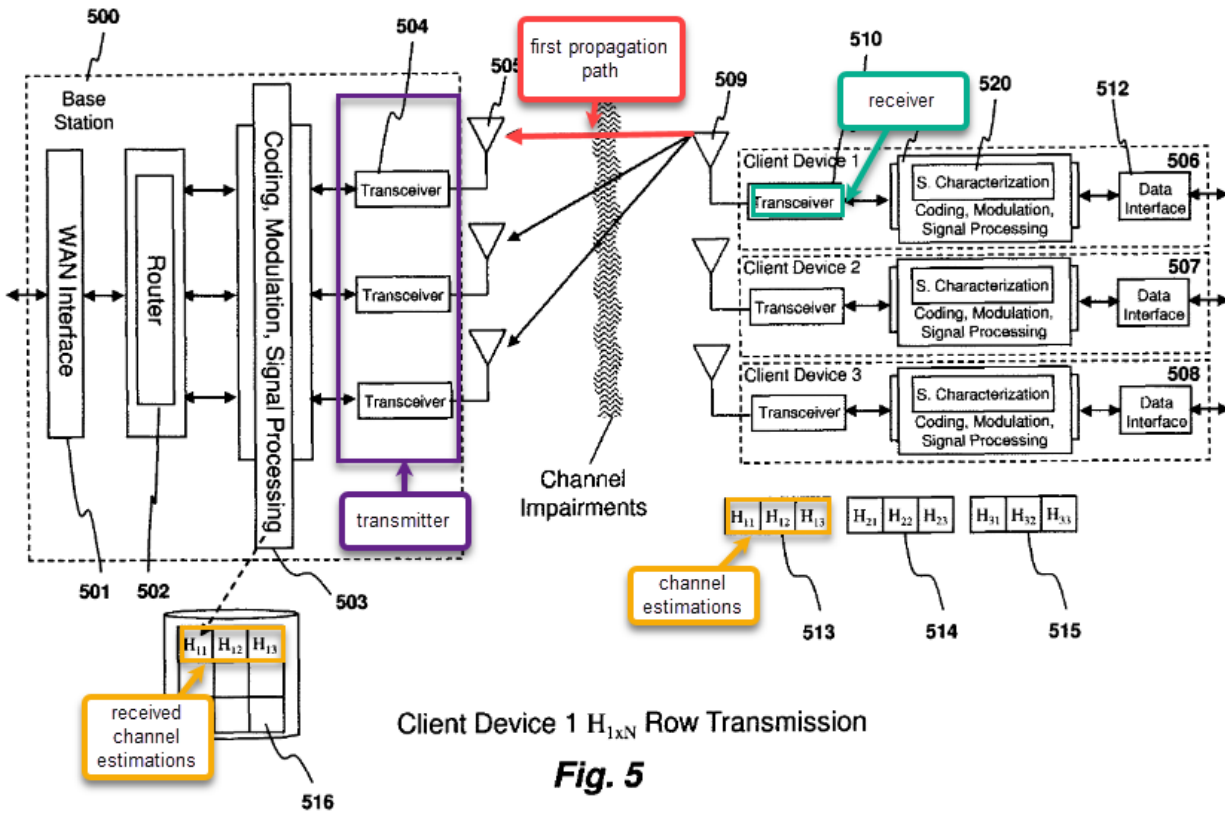
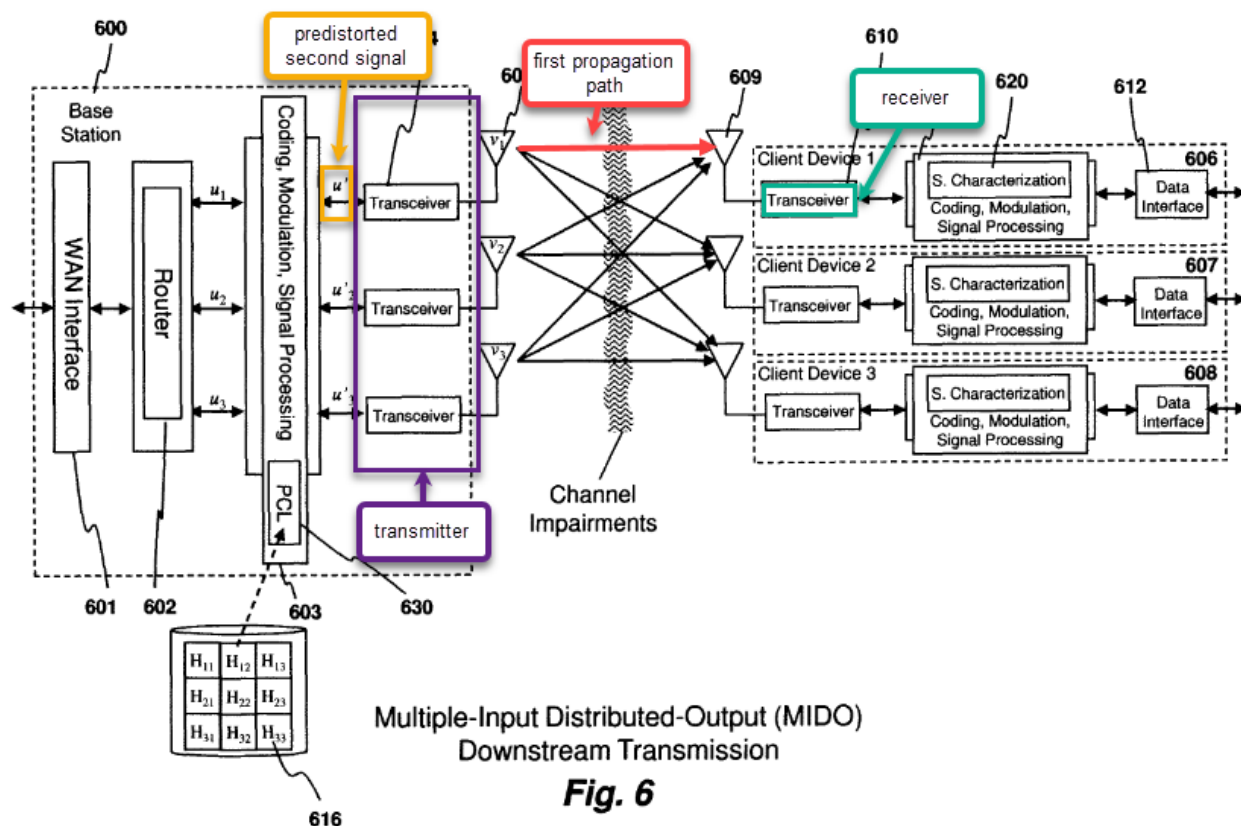


Fig. 5

278. Figure 6 depicts “signal precoding logic 630 for uniquely coding the signal transmitted from each of the antennas 605 based on the signal characterization matrix 616,” *i.e.* matrix H . The “precoding logic 630 multiplies the three bit streams u_1 - u_3 in FIG. 6 by the inverse of the H matrix 616, producing three new bit streams, u'_1 - u'_3 .” *Id.*, 32:65-67. These precoded bit streams are then transmitted to the client devices, “each such bit stream is intended for one of the three Client Devices 606-608.” *Id.*, 33:3-11.



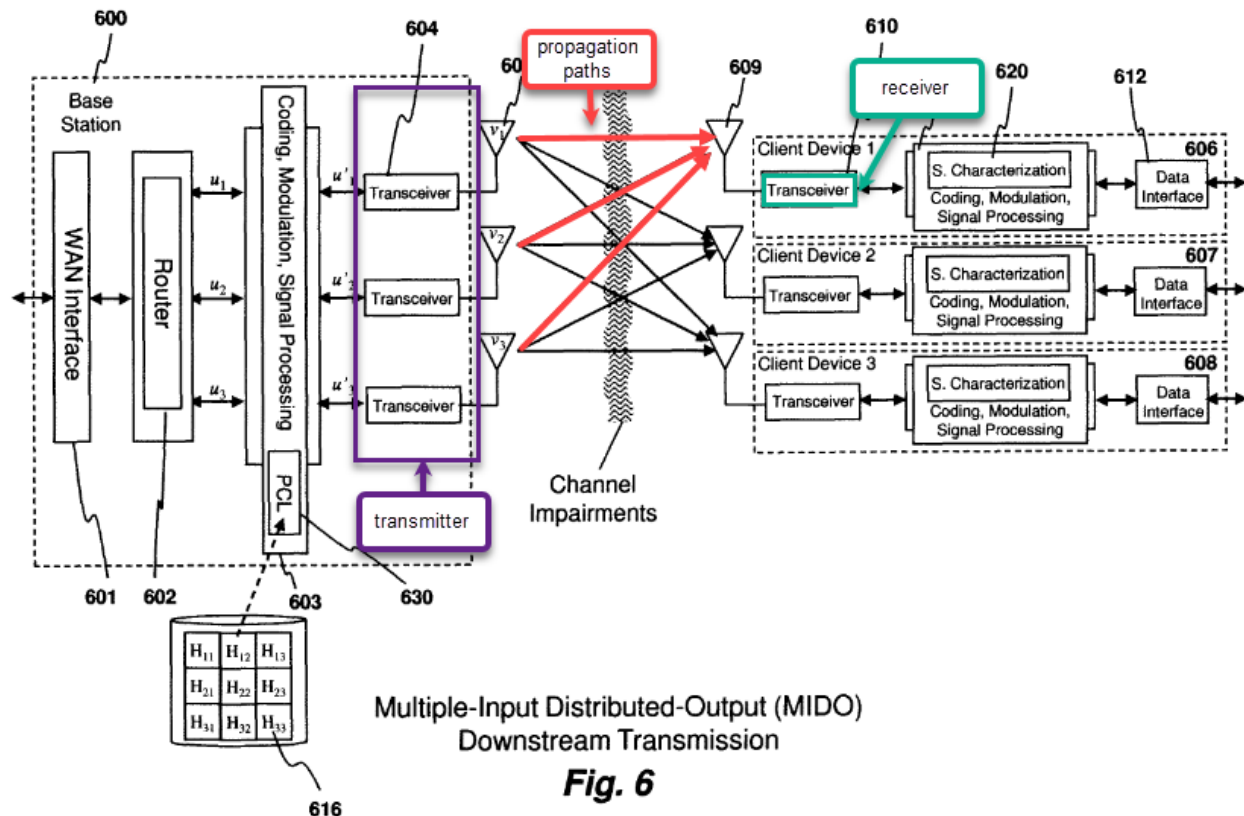
B. Independent Claim 1

[1.0] A method for wireless communication in a system including a transmitter, a receiver, and a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver, the method comprising:

279. Forenza discloses and/or renders obvious “a system including a transmitter, a receiver, and a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver.”

280. Forenza, and in particular Figure 6, discloses a base station with a transmitter comprising multiple antennas that each transmit a signal to receivers (such as client devices), where each signal travels on a propagation path. For example, in

the annotated version of Figure 6 below, base station 500 transmits training signals to client device 1 along three different propagation paths highlighted in red. See Ex. 1014, 15:4-18. Each of these propagation paths are different propagation paths because, as Forenza explains, each antenna of the transmitter makes a “separate transmission[]” to each client device, which processes each training signal transmission through a “characterization process” in order to “characterize the resulting signal (e.g., identifying phase and amplitude distortions ...) and store[] the characterization in memory.” Ex. 1014, 31:18-26.



281. These characterizations are actually characterizations of each channel.

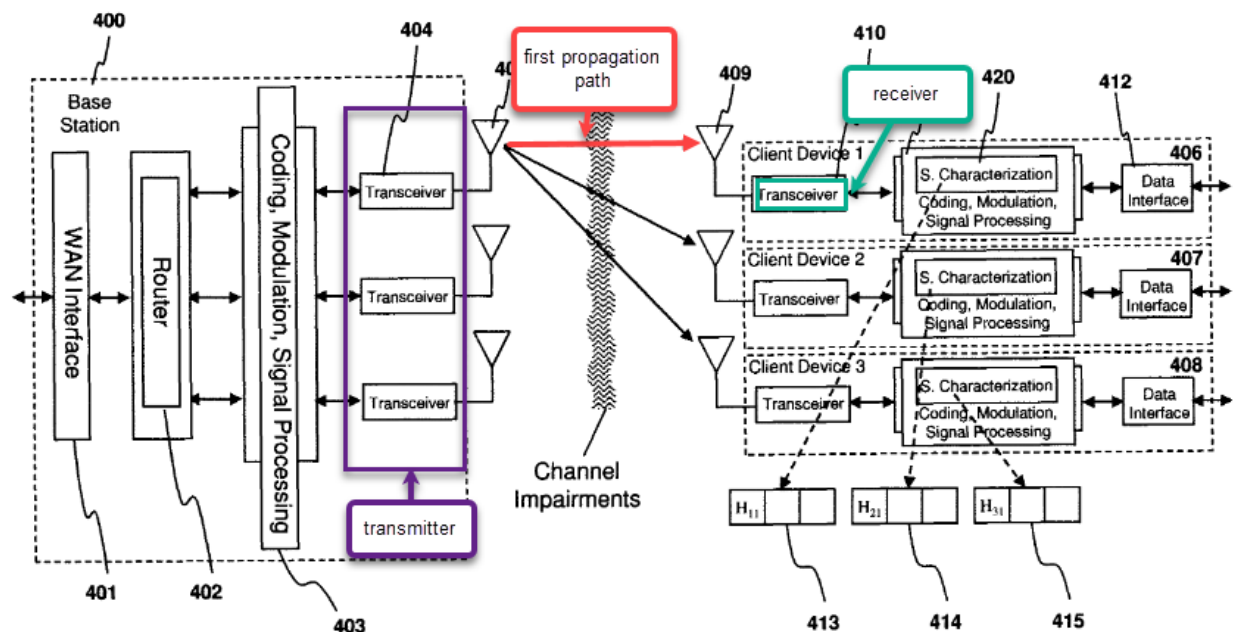
Id., 26:39-40. The characterization “may include many factors including, for example,

phase and amplitude relative to a reference internal to the receiver, an absolute reference, a relative reference, characteristic noise, or other factors.” *Id.*, 26:50-54. The characterization is further “typically defined as a vector that characterizes phase and amplitude changes of several aspects of the signal when it is transmitted across the channel.” *Id.*, 26:54-57. A POSITA would understand that such characteristics are characteristics of the propagation path that the signal takes. Because Forenza discloses that a characterization is generated and stored for each transmission, a POSITA would understand that the transmitted signals travel on different propagation paths, as it would otherwise be unnecessary to generate and store each channel’s characterization.

[1.1] transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths;

282. Forenza discloses and/or renders obvious “transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths.”

283. Forenza, and in particular Figure 4 (annotated below), teaches that the base station transmits a signal to the first client device via a first propagation path. Forenza teaches that “a training signal is transmitted ..., one-by-one, by each of the antennas 405,” with Figure 4 depicting “the first training signal transmission” of the “three separate transmissions in total.” Ex. 1014, 31:6-10.



Antenna 1 Pilot Signal Transmission

Fig. 4

[1.2] receiving the first signal at the receiver;

284. Forenza discloses and/or renders obvious “receiving the first signal at the receiver.”

285. Forenza discloses that “[e]ach Client Device 406-408 receives a training signal through its antenna 409.” Ex. 1014, 31:18-19.

[1.3] performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path;

286. Forenza discloses and/or renders obvious “performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path.”

287. Forenza discloses that the client device generates a channel characterization (*i.e.* **channel estimation**) based on the training signal. Ex. 1014, 31:18-26. The characterization “may include many factors including, for example, phase and amplitude relative to a reference internal to the receiver, an absolute reference, a relative reference, characteristic noise, or other factors,” all of which are examples of path parameter information (as construed by Patent Owner). *Id.*, 26:50-54; *see also* 31:18-26 (“identifying phase and amplitude distortions”). The characterization can be a “vector of phase/amplitude offsets” containing “some fixed number of phase and amplitude offsets” such as “eight.” *Id.*, 31:43-46. Forenza labels these vectors as H_{nm} , where n is the client device and m is the propagation path. These vectors are stored in memory at the client devices. *Id.*, 31:50-59.

288. Forenza also describes such characterizations as CSI, *i.e.* channel state information. *Id.*, 15:4-18 (describing Figures 4-6, thereby confirming this description is the same embodiment). As I discussed above, CSI is path parameter information as construed by Patent Owner.

289. Forenza also discloses that the user device estimates channel information that is later used by the base station to compute a “precoding matrix to cancel inter-carrier and inter-user interference caused by I/Q [in-phase and quadrature] imbalance.” *Id.*, 37:12-20. In particular, the user device comprises “channel estimation logic” that “estimates the channels ... via training symbols and feedbacks

these estimates to the precoder 1302 within the AP.” *Id.*, 43:66-44:2. A POSITA would understand that these channel estimates contain path parameter information (as construed by Patent Owner) used to cancel “interference due to I/Q gain and phase imbalance.” *Id.*, 44:3-4, 41:64-42:25. These teachings are part of the same embodiment as the teachings with respect to Figures 3-6 because this section describes a method “to compensate for in-phase and quadrature (I/Q) imbalance in distributed-input distributed-output (DIDO) systems with orthogonal frequency division multiplexing (OFDM).” *Id.*, 37:12-15. The embodiment in Figures 3-6 is a DIDO system with OFDM. *See* Ex. 1014, Fig. 2 (depicting a DIDO system comprising a base station with multiple antennas and user devices with single antennas), Fig. 3 (depicting a MIDO system comprising the same); 15:4-18 (describing Figures 4-6 as depicting DIDO distributed antennas); 27:38-31 (including OFDM as “[a]n appropriate modulation scheme” for the Figures 3-6 embodiment).

290. To the extent Patent Owner argues that these disclosures are from different embodiments, it is my opinion it would have been obvious to a POSITA to combine the two embodiments. For clarity, I will denote the first embodiment as the “Figures 3-6 embodiment” and the second embodiment as the “I/Q Imbalance embodiment.” A POSITA would have been motivated to modify the Figures 3-6 embodiment to include channel estimations from the I/Q Imbalance embodiment, as this would allow for cancelation of inter-carrier and inter-user interference. Indeed,

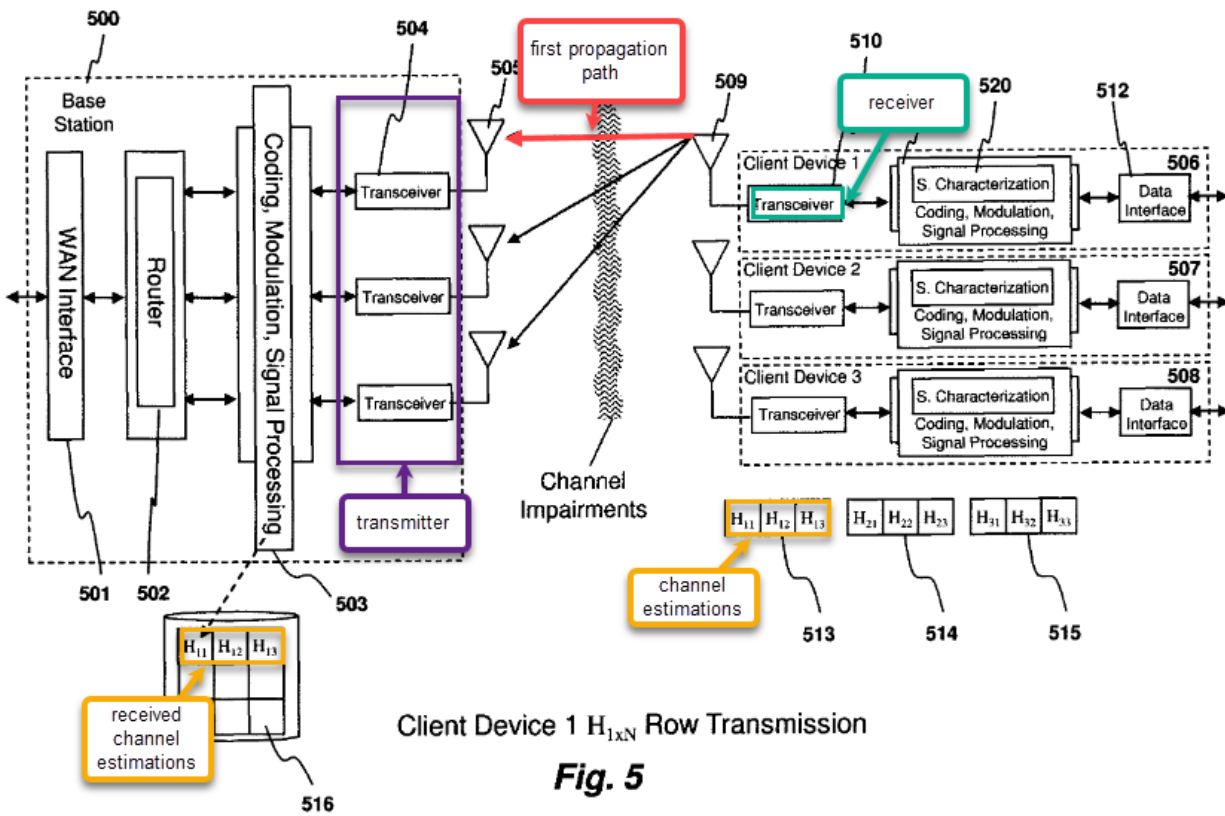
Forenza describes that the process for calculating channel estimations for I/Q Imbalance embodiment is similar to the process for calculating phase and amplitude offsets in the Figures 3-6 embodiment—specifically, that both involve user devices deriving channel estimates from training signals sent from the base station, and then sending those channel estimates to the base station for generating a precoding matrix.

291. Moreover, Forenza describes that the I/Q Imbalance embodiment is “a system and method to compensate for in-phase and quadrature (I/Q) imbalance in distributed-input distributed-output (DIDO) systems with orthogonal frequency division multiplexing (OFDM).” Ex. 1014, 37:12-16. A POSITA would understand that a DIDO-OFDM is the same system as the MIDO-OFDM system described in the Figures 3-6 embodiment. *See* Ex. 1014, Fig. 2 (depicting a DIDO system comprising a base station with multiple antennas and user devices with single antennas), Fig. 3 (depicting a MIDO system comprising the same); 15:4-18 (describing Figures 4-6 as depicting DIDO distributed antennas); 27:38-31 (including OFDM as “[a]n appropriate modulation scheme” for the Figures 3-6 embodiment). Given these compatibilities, a POSITA would have reasonably expected the combination to succeed.

[1.4] sending the channel estimation that includes the path parameter information from the receiver to the transmitter via the first propagation path;

292. Forenza discloses and/or renders obvious “sending the channel estimation that includes the path parameter information from the receiver to the transmitter via the first propagation path.”

293. Forenza discloses that after all training signals are sent and each client device generates channel characterizations for them (*i.e.* H vectors which are collectively stored as matrix H), “each Client Device 506-508 transmits back to the Base Station 500 the 1x3 row 513-515 of matrix H that it has stored.” *Id.*, 32:8-10. This process is depicted in Figure 5, annotated below, which shows that the characterizations (*i.e.* ***channel estimation***) are sent to the base station via the same propagation paths as the training signals depicted in Figure 4.



[1.5] predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain, according to the channel estimation based on the first signal;

294. Forenza discloses and/or renders obvious “predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain, according to the channel estimation based on the first signal” in light of Patent Owner’s apparent interpretation of this limitation based on its infringement contentions in the related district court proceedings. As discussed above, Patent Owner seems to interpret “predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain” as broad enough to include beamforming (using precoding) a wireless signal.

295. Forenza discloses, including in Figure 6, that the base station “includes signal precoding logic 630 for uniquely coding the signals transmitted from each of the antennas 605 based on the signal characterization matrix 616.” Ex. 1014, 32:59-62. As discussed above, the term “predistorting” includes precoding of signals based on Patent Owner’s apparent construction of the term.

296. Specifically, Forenza teaches that bit streams u_1 , u_2 , and u_3 (*i.e.* **second signals**) are precoded by multiplying them “by the inverse of the H matrix 616 [*i.e.* **channel estimations**], producing three new bit streams, u'_1 - u'_3 .” *Id.*, 32:65-67.

297. As I discussed above, the H matrix contains phase and amplitude offsets that are characteristic of each propagation path. A POSITA would understand that precoding a signal using phase and amplitude offsets would result in modulating the signal in a time, frequency, and spatial domain. Specifically, when offsetting a portion of a signal’s phase or amplitude, this results in modulating the signal in the time, frequency, and spatial domain.

298. Forenza further teaches that these characterizations are also called CSI (channel state information), and that “[f]rom the received CSI, the BS computes the link quality metrics in time/frequency/space domains,” which are used for precoding. Ex. 1014, 51:38-46.

299. In addition, Forenza teaches that the I/Q Imbalance embodiment, which as discussed above would have been obvious to incorporate with Forenza’s

Figures 3-6 embodiment, uses “an I/Q mismatch aware DIDO precoder at the station ... that uses I/Q channel information to perform functions including ... space-time-frequency mapping,” *i.e.* precoding in a space, time, and frequency domain. Ex. 1014, 37:58-62; *see also* 46:40-47 (“configurator that uses an IQ-aware channel estimate ... to configure the DIDO IQ-aware precoder, choose the modulation rate, coding rate ... and their mappings to space-time-frequency code slots”); 52:11-15 (“[D]ifferent DIDO modes can be assigned to different time slots ... such that the adaptation may occur in time, frequency and space domains.”). A POSITA would understand these teachings to refer to a precoder that uses modulating and coding rates that are specific to the space, time, and frequency domains.

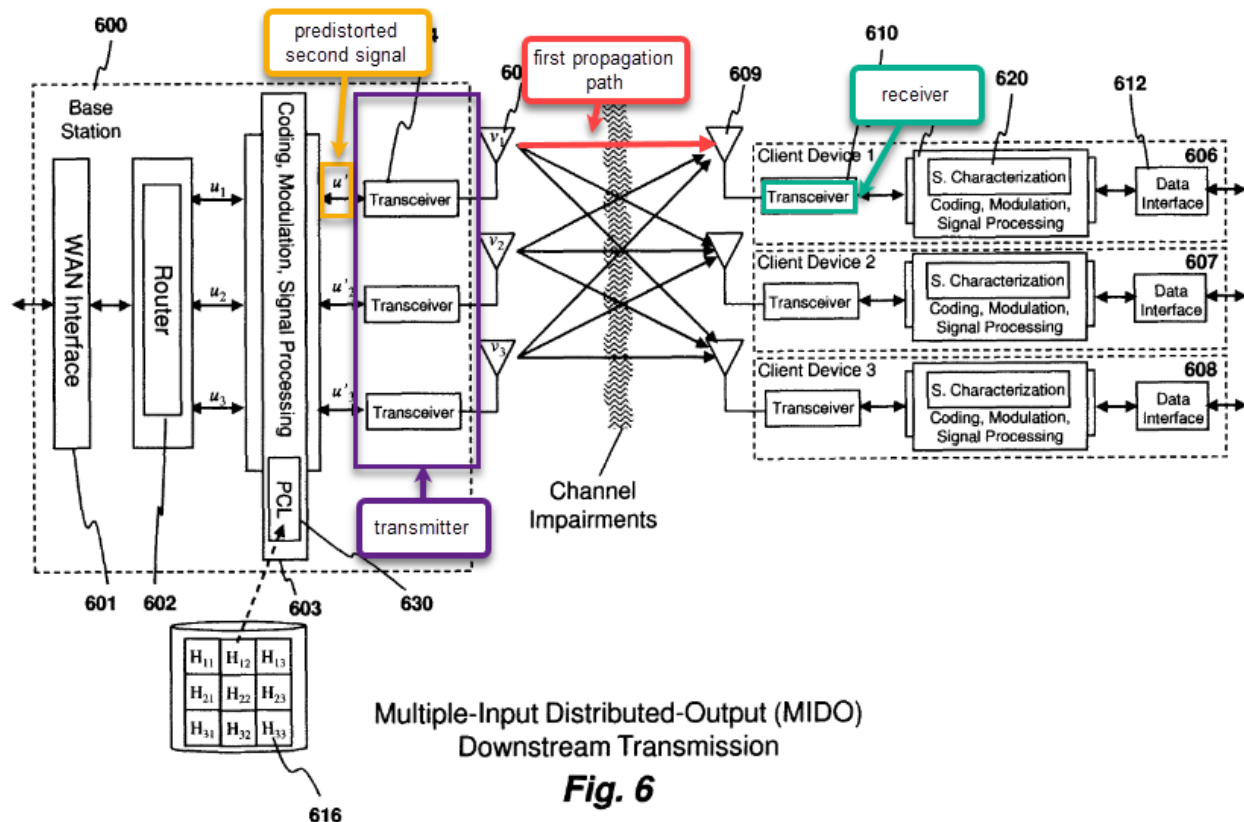
[1.6] transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path; and

300. Forenza discloses and/or renders obvious “transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path.”

301. I incorporate the discussion provided above with respect to claim elements **[1.4]** and **[1.5]** of Claim 1.

302. Forenza discloses that the precoded bitstreams (*i.e.* ***predistorted second signal***) are “transmitted as RF by Tranceivers 604 and antennas 605” (*i.e.* ***transmitter***) and “received by the Client Devices 606-608” (*i.e.* ***receiver***). Ex. 1014,

33:1-5. As depicted in Figure 6, annotated below, the precoded bitstreams are transmitted via the same first propagation path as the training signals from Figure 4.



[1.7] receiving the predistorted second signal at the receiver.

303. Forenza discloses and/or renders obvious “receiving the predistorted second signal at the receiver.”

304. I incorporate the discussion provided above with respect to claim elements [1.2], [1.4], and [1.5] of Claim 1.

305. As I discussed above in claim element [1.5], the precoded bitstream is “received by the Client Devices 606-608.” Ex. 1014, 33:1-5.

C. Dependent Claim 2

306. Claim 2 depends from Claim 1, and thus the discussion above with respect to Claim 1 is incorporated by reference. Forenza also discloses and/or renders obvious the additional limitation of Claim 2: “wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.”

307. As I discussed above, Forenza discloses a path parameter information in the form of phase offset, which a POSITA would understand to be an estimation of a delay because a phase offset is a modulation in the time domain.

308. Forenza also teaches that “I/Q imbalance” path parameter information includes “delay imbalance.” Ex. 1014, 44:57-58.

D. Dependent Claim 3

309. Claim 3 depends from Claim 2 which depends from Claim 1, and thus the discussions above with respect to Claim 1 and Claim 2 are incorporated by reference. Forenza also discloses and/or renders obvious the additional limitation of Claim 3: “wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.”

310. Forenza discloses that “one embodiment of the invention polarizes the signal in order to increase the effective throughput of the system.” Ex. 1014, 29:7-9. A POSITA would understand that in order for the base station to polarize the signal, it would need to know the polarization status of the propagation path for that signal, and thus a POSITA would understand Forenza to be teaching that the polarization status to the base station as part of the channel state information.

E. Dependent Claim 4

311. Claim 4 depends from Claim 1, and thus the discussion above with respect to Claim 1 is incorporated by reference. Forenza also discloses and/or renders obvious the additional limitation of Claim 4: “wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum-likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least- square-error methods.”

312. I incorporate the discussion provided above with respect to Claim 2.

313. Further, Forenza discloses “estimat[ing] the carrier frequency offset at the receiver,” which it discloses can be calculated using ESPRIT. Ex. 1014, 59:47-63 (“OFDM blind carrier offset estimation: ESPRIT”).

F. Dependent Claim 6

314. Claim 6 depends from Claim 1, and thus the discussion above with respect to Claim 1 is incorporated by reference. Forenza also discloses and/or renders obvious the additional limitation of Claim 6: “equalizing the predistorted second signal at the receiver.”

315. As I discussed above in Ground 1, equalizing is applicant admitted prior art. Moreover, Forenza discloses that “user devices demodulate data via zero-forcing (ZF), [and] minimum mean-square error (MMSE),” including precoded data. Ex. 1014, 37:21-23. A POSITA would understand that ZF and MMSE are known algorithms for performing equalization of a signal.

G. Dependent Claim 7

316. Claim 7 depends from Claim 6 which depends from Claim 1, and thus the discussions above with respect to Claim 1 and Claim 6 are incorporated by reference. Forenza also discloses and/or renders obvious the additional limitation of Claim 7: “wherein equalizing the predistorted second signal is performed using a joint processing technique in a coordinated multiple-point (CoMP) system.”

317. As I discussed above in Ground 1, the use of CoMP is applicant admitted prior art. It is also my opinion that a POSITA would have found it obvious to use CoMP in Forenza's system because it is the application of a known technique to a known device ready for improvement to yield predictable results.

H. Independent Claim 8

[8.0] A system for wireless communication comprising:

318. Forenza discloses a "system for wireless communication."

319. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[8.1] a receiver;

320. Forenza discloses and/or renders obvious "a receiver."

321. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[8.2] a transmitter; and

322. Forenza discloses and/or renders obvious "a transmitter."

323. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[8.3] a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver,

324. Forenza discloses and/or renders obvious “a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver.”

325. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[8.4] wherein the receiver is configured to receive a first signal that is transmitted along a first propagation path of the plurality of propagation paths from the transmitter, perform a channel estimation based on the first signal to obtain path parameter information of the first propagation path, and send the channel estimation that includes the path parameter information to the transmitter via the first propagation path, and

326. Forenza discloses and/or renders obvious “the receiver is configured to receive a first signal that is transmitted along a first propagation path of the plurality of propagation paths from the transmitter, perform a channel estimation based on the first signal to obtain path parameter information of the first propagation path, and send the channel estimation that includes the path parameter information to the transmitter via the first propagation path.”

327. I incorporate the discussion provided above with respect to claim elements **[1.1]**, **[1.2]**, **[1.3]**, and **[1.4]** of Claim 1.

[8.5] wherein the transmitter is configured to predistort a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation that is based on the first signal and received from the

receiver and to transmit the predistorted second signal to the receiver via the first propagation path.

328. Forenza discloses and/or renders obvious “the transmitter is configured to predistort a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation that is based on the first signal and received from the receiver and to transmit the predistorted second signal to the receiver via the first propagation path.”

329. I incorporate the discussion provided above with respect to claim elements [1.5], [1.6], and [1.7] of Claim 1.

I. Dependent Claim 9

330. Claim 9 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Forenza discloses and/or renders obvious “wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.”

331. I incorporate the discussion provided above with respect to Claim 2.

J. Dependent Claim 10

332. Claim 10 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Forenza discloses and/or renders

obvious “wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.”

333. I incorporate the discussion provided above with respect to Claim 3.

K. Dependent Claim 11

334. Claim 11 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Sesia discloses and/or renders obvious “wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least square-error methods.”

335. I incorporate the discussion provided above with respect to Claim 4.

L. Dependent Claim 12

336. Claim 12 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Forenza also discloses and/or renders obvious the additional limitation of Claim 12: “wherein the transmitter and the receiver each comprise multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.”

337. Forenza teaches that within the prior art were MIMO systems where a multi-antenna base station sends training signals to a multi-antenna user device and receives channel characterizations to generate a precoding matrix, as described above for claim 1. Ex. 1014, 26:31-28:14, Fig. 1. Forenza also discloses that one embodiment of its invention “employs MIMO techniques” as depicted in Figure 7. *Id.*, 34:7-36.

M. Dependent Claim 14

338. Claim 14 depends from Claim 8, and thus the discussion above with respect to Claim 8 is incorporated by reference. Forenza discloses and/or renders obvious “wherein the receiver is further configured to equalize the predistorted second signal.”

339. I incorporate the discussion provided above with respect to Claim 6.

N. Independent Claim 15

[15.0] A base station for performing wireless communication with a receiver in a wireless device via a plurality of propagation paths, the base station comprising:

340. Forenza discloses and/or renders obvious “[a] base station for performing wireless communication with a receiver in a wireless device via a plurality of propagation paths.”

341. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[15.1] a transmitter;

342. Forenza discloses and/or renders obvious “a transmitter.”

343. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[15.2] a computing device; and

344. Forenza discloses and/or renders obvious “a computing device.”

345. Forenza discloses that “the Base Stations/APs” described in it specification “may be implemented as software executed on a general purpose or special purpose processor.” Ex. 1014, 75:43-46.

[15.3] a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations comprising:

346. Forenza discloses and/or renders obvious “a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations.”

347. Forenza discloses “machine-readable medium for storing the machine-executable instructions” used to perform the methods described in Forenza. *Id.*, 76:1-8.

[15.3.1] transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths;

348. Forenza discloses and/or renders obvious “transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths.”

349. I incorporate the discussion provided above with respect to claim element **[1.1]** of Claim 1.

[15.3.2] receiving a channel estimation based on the first signal, the channel estimation including path parameter information of the first propagation path;

350. Forenza discloses and/or renders obvious “receiving a channel estimation based on the first signal, the channel estimation including path parameter information of the first propagation path.”

351. I incorporate the discussion provided above with respect to claim elements [1.2], [1.3], and [1.4] of Claim 1.

[15.3.3] predistorting a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal; and

352. Forenza discloses and/or renders obvious “predistorting a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.”

353. I incorporate the discussion provided above with respect to [1.5] of Claim 1.

[15.3.4] transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path.

354. Forenza discloses and/or renders obvious “transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path.”

355. I incorporate the discussion provided above with respect to claim element [1.6] of Claim 1.

O. Dependent Claim 16

356. Claim 16 depends from Claim 15, and thus the discussion above with respect to Claim 15 is incorporated by reference. Forenza discloses and/or renders obvious “wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an

estimation of a direction of arrival, an estimation of a direction of departure, an estimation of a complex amplitude of the first propagation path, and an estimation of a polarization status of the first propagation path.”

357. I incorporate the discussion provided above with respect to Claim 2.

P. Dependent Claim 17

358. Claim 17 depends from Claim 15, and thus the discussion above with respect to Claim 15 is incorporated by reference. Forenza discloses and/or renders obvious “wherein the transmitter comprises multiple antennas in a multiple-input and multiple- output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.”

359. I incorporate the discussion provided above with respect to Claim 12.

Q. Independent Claim 19

[19.0] A wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths, the wireless device comprising:

360. Forenza discloses and/or renders obvious “[a] wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths.”

361. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1 and Claim 6.

[19.1] a receiver;

362. Forenza discloses and/or renders obvious “a receiver.”

363. I incorporate the discussion provided above with respect to claim element **[1.0]** of Claim 1.

[19.2] a computing device; and

364. Forenza discloses and/or renders obvious “a computing device.”

365. I incorporate the discussion provided above with respect to claim element **[15.2]** of Claim 15.

[19.3] a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations comprising:

366. Forenza discloses and/or renders obvious “a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations.”

367. I incorporate the discussion provided above with respect to claim element **[15.3]** of Claim 15.

[19.3.1] receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths;

368. Forenza discloses and/or renders obvious “receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths.”

369. I incorporate the discussion provided above with respect to claim elements **[1.1]** and **[1.2]** of Claim 1.

[19.3.2] performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path;

370. Forenza discloses and/or renders obvious “performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path.”

371. I incorporate the discussion provided above with respect to claim element **[1.3]** of Claim 1.

[19.3.3] sending the channel estimation that includes the path parameter information to the transmitter; and

372. Forenza discloses and/or renders obvious “sending the channel estimation that includes the path parameter information to the transmitter.”

373. I incorporate the discussion provided above with respect to claim element **[1.4]** of Claim 1.

[19.3.4] receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.

374. Forenza discloses and/or renders obvious “receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.”

375. I incorporate the discussion provided above with respect to claim elements **[1.5]**, **[1.6]**, and **[1.7]** of Claim 1.

R. Dependent Claim 20

376. Claim 20 depends from Claim 19, and thus the discussion above with respect to Claim 19 is incorporated by reference. Forenza discloses and/or renders obvious “wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.”

377. I incorporate the discussion provided above with respect to Claim 2.

S. Dependent Claim 21

378. Claim 21 depends from Claim 20 which depends from Claim 19, and thus the discussions above with respect to Claim 19 and Claim 20 are incorporated by reference. Forenza discloses and/or renders obvious “wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.”

379. I incorporate the discussion provided above with respect to Claim 3.

T. Dependent Claim 22

380. Claim 22 depends from Claim 19, and thus the discussion above with respect to Claim 19 is incorporated by reference. Forenza discloses and/or renders obvious “wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon

beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT(Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation- maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.”

381. I incorporate the discussion provided above with respect to Claim 4.

U. Dependent Claim 23

382. Claim 23 depends from Claim 19, and thus the discussion above with respect to Claim 19 is incorporated by reference. Forenza discloses and/or renders obvious “wherein the receiver comprises multiple antennas in a multiple-input and multiple- output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.”

383. I incorporate the discussion provided above with respect to Claim 12.

X. CONCLUSION

384. I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willful false

statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this proceeding.

Executed on this December 18, 2023 by:



Kevin C. Almeroth, Ph. D.

XI. CLAIM LISTING

Elem.	Claims 1-7
[1.0]	A method for wireless communication in a system including a transmitter, a receiver, and a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver, the method comprising:
[1.1]	transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths;
[1.2]	receiving the first signal at the receiver;
[1.3]	performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path;
[1.4]	sending the channel estimation that includes the path parameter information from the receiver to the transmitter via the first propagation path;
[1.5]	predistorting a second signal at the transmitter in a time domain, a frequency domain, and a spatial domain, according to the channel estimation based on the first signal;
[1.6]	transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path; and
[1.7]	receiving the predistorted second signal at the receiver.
[2]	The method of claim 1, wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.
[3]	The method of claim 2, wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.
[4]	The method of claim 1, wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum-likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.
[6]	The method of claim 1, further comprising equalizing the predistorted second signal at the receiver.
[7]	The method of claim 6, wherein equalizing the predistorted second signal is performed using a joint processing technique in a coordinated multiple-point (CoMP) system.

Elem.	Claims 8-12, 14
[8.0]	A system for wireless communication comprising:
[8.1]	a receiver;
[8.2]	a transmitter; and
[8.3]	a plurality of propagation paths formed between the transmitter and the receiver which are capable of carrying a signal transmitted by the transmitter to the receiver,
[8.4]	wherein the receiver is configured to receive a first signal that is transmitted along a first propagation path of the plurality of propagation paths from the transmitter, perform a channel estimation based on the first signal to obtain path parameter information of the first propagation path, and send the channel estimation that includes the path parameter information to the transmitter via the first propagation path, and
[8.5]	wherein the transmitter is configured to predistort a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation that is based on the first signal and received from the receiver and to transmit the predistorted second signal to the receiver via the first propagation path.
[9]	The system of claim 8, wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.
[10]	The system of claim 8, wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.
[11]	The system of claim 8, wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.
[12]	The system of claim 8, wherein the transmitter and the receiver each comprise multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.
[14]	The system of claim 8, wherein the receiver is further configured to equalize the predistorted second signal.

Elem.	Claims 15-17
[15.0]	A base station for performing wireless communication with a receiver in a wireless device via a plurality of propagation paths, the base station comprising:
[15.1]	a transmitter;
[15.2]	a computing device; and
[15.3]	a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations comprising:
[15.3.1]	transmitting a first signal from the transmitter to the receiver via a first propagation path of the plurality of propagation paths;
[15.3.2]	receiving a channel estimation based on the first signal, the channel estimation including path parameter information of the first propagation path;
[15.3.3]	predistorting a second signal in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal; and
[15.3.4]	transmitting the predistorted second signal from the transmitter to the receiver via the first propagation path.
[16]	The base station of claim 15, wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, an estimation of a complex amplitude of the first propagation path, and an estimation of a polarization status of the first propagation path.
[17]	The base station of claim 15, wherein the transmitter comprises multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.

Elem.	Claims 19-23
[19.0]	A wireless device for performing wireless communication with a base station with a transmitter via a plurality of propagation paths, the wireless device comprising:
[19.1]	a receiver;
[19.2]	a computing device; and
[19.3]	a computer-readable storage medium having computer-executable instructions stored thereon that are executable by the computing device to perform operations comprising:
[19.3.1]	receiving a first signal at the receiver via a first propagation path of the plurality of propagation paths;
[19.3.2]	performing a channel estimation based on the first signal to obtain path parameter information of the first propagation path;
[19.3.3]	sending the channel estimation that includes the path parameter information to the transmitter; and
[19.3.4]	receiving a second signal via the first propagation path, the second signal predistorted in a time domain, a frequency domain, and a spatial domain according to the channel estimation based on the first signal.
[20]	The wireless device of claim 19, wherein the path parameter information of the first propagation path includes at least one of an estimation of a delay, an estimation of a Doppler frequency, an estimation of a direction of arrival, an estimation of a direction of departure, and an estimation of a complex amplitude of the first propagation path.
[21]	The wireless device of claim 20, wherein the path parameter information of the first propagation path further includes an estimation of a polarization status of the first propagation path.
[22]	The wireless device of claim 19, wherein the path parameter information is obtained by at least one estimation technique of the group consisting of a maximum likelihood estimation algorithm, periodogram, correlatorgram, spectral-based methods, Bartlett beamformers, Capon beamformers, subspace-based techniques, MUSIC (Multiple Signal Classification), ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques), approximation of the maximum-likelihood method based on iterative schemes, SAGE (Space-Alternating Generalized Expectation-maximization), RiMAX (Richter's Maximum Likelihood method), maximum-a-posteriori based methods, Evidence Framework, Bayesian techniques, tracking algorithms, Kalman filtering techniques, enhanced Kalman filtering techniques, particle filtering techniques, and least-square-error methods.
[23]	The wireless device of claim 19, wherein the receiver comprises multiple antennas in a multiple-input and multiple-output (MIMO) wireless communication system or a single antenna in a single-input and single-output (SISO) wireless communication system.