

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS AMERICA, INC.,
SAMSUNG ELECTRONICS CO., LTD.,
Petitioners,

v.

COLLISION COMMUNICATIONS, INC.,
Patent Owner.

Case No. IPR2024-01500

U.S. Patent No. 7,463,703

DECLARATION OF PAUL S. MIN, PH.D.
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 7,463,703

TABLE OF CONTENTS

I.	Introduction.....	1
II.	Qualifications and Background	1
III.	Legal Standards	6
	A. Claim Construction.....	6
	B. Anticipation Under 35 U.S.C. § 102	7
	C. Obviousness Under 35 U.S.C. § 103.....	8
IV.	The '703 patent.....	11
	A. Background of Technology	11
	B. Overview of the '703 patent.....	15
	C. Prosecution History of the '703 patent.....	18
	D. Person of Ordinary Skill in the Art	18
V.	Claim Construction of Terms of the '703 patent.....	20
VI.	Overview of Prior Art.....	20
	A. Brommer.....	20
	B. Learned	23
	C. Frank.....	24
	D. Lilleberg	25
	E. ElGamal.....	26
	F. Hottinen	27
	G. Zha	28
VII.	Summary of Opinions on Unpatentability.....	30

A.	Ground 1: Claims 1-3 are Rendered Obvious by Brommer in view of Lilleberg and Hottinen	31
1.	Motivation to Combine and Reasonable Expectation of Success	31
2.	Claim 1	36
3.	Claim 2: “The apparatus according to claim 1, wherein said final condition is selected from at least one of the group consisting of bit error rate metric level and fixed number of iterations.	47
4.	Claim 3: “The apparatus according to claim 1, wherein said symbol estimator is a member selected from at least one member of the group consisting of Minimum Mean Squared Error (MMSE), maximum likelihood, M-algorithm, T-algorithm, and Q-algorithm, decorrelating decision-feedback detector (DDFD), improved decorrelating decision-feedback detector (IDDFD), successive interference cancellation (SIC), parallel interference cancellation (PIC) and multi-stage detector; block-iterative interference cancellation, and a deferred decorrelating decision-feedback detector.”.....	48
B.	Ground 2: Claim 4 Is Rendered Obvious in view of Brommer, Lilleberg, Hottinen, and Learned	49
1.	Motivation to Combine and Reasonable Expectation of Success	50
2.	Claim 4: “The apparatus according to claim 1, further comprising an energy detector coupled to said joint amplitude estimator.”.....	53
C.	Ground 3: Claim 5 Is Rendered Obvious in view of Brommer, Lilleberg, Hottinen, and ElGamal	54
1.	Motivation to Combine and Reasonable Expectation of Success	55

2.	Claim 5: “The apparatus according to claim 1, wherein said bank of decoders are decoders selected from at least one decoder of the group consisting of Soft-output Viterbi, Maximum A Posteriori, and Bahl-Cocke-Jelinek-Raviv.”	58
D.	Ground 4: Claims 1-3 and 5 are Rendered Obvious by Frank in view of Zha.....	59
1.	Motivation to Combine and Reasonable Expectation of Success	59
2.	Claim 1	61
3.	Claim 2: “The apparatus according to claim 1, wherein said final condition is selected from at least one of the group consisting of bit error rate metric level and fixed number of iterations.	70
4.	Claim 3: “The apparatus according to claim 1, wherein said symbol estimator is a member selected from at least one member of the group consisting of Minimum Mean Squared Error (MMSE), maximum likelihood, M-algorithm, T-algorithm, and Q-algorithm, decorrelating decision-feedback detector (DDFD), improved decorrelating decision-feedback detector (IDDFD), successive interference cancellation (SIC), parallel interference cancellation (PIC) and multi-stage detector; block-iterative interference cancellation, and a deferred decorrelating decision-feedback detector.”	71
5.	Claim 5: “The apparatus according to claim 1, wherein said bank of decoders are decoders selected from at least one decoder of the group consisting of Soft-output Viterbi, Maximum A Posteriori, and Bahl-Cocke-Jelinek-Raviv.”	72
E.	Ground 5: Claim 4 Is Rendered Obvious by Frank in view of Zha and Learned.	72
1.	Motivation to Combine and Reasonable Expectation of Success	73

2.	Claim 4: “The apparatus according to claim 1, further comprising an energy detector coupled to said joint amplitude estimator.”	75
VIII.	Secondary Considerations of Non-obviousness	76
IX.	Conclusion	77

TABLE OF EXHIBITS LIST

Ex.	Description
1001	U.S. Patent No. 7,463,703 (“’703 Patent”)
1002	Prosecution History for 7,463,703
1003	Intentionally Omitted
1004	U.S. Patent No. 6,826,140 (“Brommer”)
1005	U.S. Patent No. 7,190,743 (“Learned”)
1006	U.S. Patent Pub. No. 2003/0035469 (“Frank”)
1007	U.S. Patent No. 5,905,946 (“Lilleberg”)
1008	U.S. Patent No. 6,898,248 (“ElGamal”)
1009	U.S. Patent No. 5,995,499 (“Hottinen”)
1010	Zha <i>et al.</i> , “Soft-Decision Successive Interference Cancellation CDMA Receiver with Amplitude Averaging and Robust to Timing Errors,” <i>in</i> Proc. IEEE Global Telecommunications Conference, 2001 (GLOBECOM ’01), vol. 2, 2001, pp. 743-747
1011	Sergio Verdu “Computational Complexity of Optimum Multiuser Detection,” <i>Algorithmica</i> (1989)
1012	Verdu, Sergio, “Multiuser Detection,” Cambridge University Press (1998)
1013	Shimon Moshavi, “Multi-User Detection for DS-CDMA Communications,” <i>in</i> IEEE Communications Magazine, Oct. 1996, pp. 124-136
1014	<i>Curriculum Vitae</i> of Dr. Paul Min

I. INTRODUCTION

1. I, Paul S. Min, Ph.D., submit this declaration to state my opinions on the matter described below.

2. I have been retained by Petitioners Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (“Petitioners”), as an independent expert in this proceeding before the United States Patent and Trademark Office. Although I am being compensated at my usual and customary rate of \$500 per hour, no part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I understand that this proceeding involves U.S. Patent No. 7,463,703, (the “’703 patent”), and I have been asked to consider the validity of certain claims of the ’703 patent based on certain prior art references. I have also been asked to consider the state of the art and prior art available as of April 14, 2003. Based on the prior art discussed in this declaration, it is my opinion that claims 1-5 of the ’703 patent are unpatentable for the reasons provided below.

II. QUALIFICATIONS AND BACKGROUND

4. I believe that I am well qualified to serve as a technical expert in this matter based upon my educational and work experience, and specifically, in the field of vehicle electronics and computing devices. My curriculum vitae (“CV”) is submitted as Exhibit 1014.

5. Of note, as shown in my CV, I have extensive experience design and implementation of receiver devices to be used in the cellular equipment and the WLAN equipment.

6. I received a B.S. degree in Electrical Engineering in 1982, an M.S. degree in Electrical Engineering in 1984, and a Ph.D. degree in Electrical Engineering in 1987 from the University of Michigan in Ann Arbor. I received several academic honors, including my B.S. degree with honors, a best graduate student award and a best teaching assistant award during my M.S. study, and a best paper award from a major international conference for reporting results from my Ph.D. thesis.

7. After receiving my Ph.D., I worked at Bellcore in New Jersey from August 1987 until August 1990. At Bellcore, I was responsible for evolving the public switched telephone network (POTS) into a multi-services voice and data network that incorporated packet switches, optical technologies, and wireless technologies.

8. In September 1990, I joined the faculty at Washington University in St. Louis. In July 1996, I was promoted to an Associate Professor of Electrical Engineering with tenure. I am currently a Senior Professor at Washington University of the Electrical and Systems Engineering. I have also served as the Chair of the

Graduate Curriculum (2000-2002) and the Chair of the Undergraduate Curriculum (2011-2014) for the Electrical and Systems Engineering department.

9. At Washington University, I have conducted research in communication, computing, and related electronic hardware and software. My research group has pioneered a new paradigm for designing electronic circuits that can alleviate the speed and performance mismatch against optical technology. I have received several grants from the U.S. Federal Agencies, including the National Science Foundation and the Defense Advanced Research Project Agency, and numerous contracts from companies and organizations around the world. Specifically related to the technology matters in this Investigation, I have researched a variety of wireless communication technologies, including CDMA, WCDMA, OFDM, FDD, SC-FDMA, and TDD. I have an extensive background and experience in each of these technologies.

10. As a faculty member at Washington University, I have taught a number of courses in electronics, communication, and computing at both the undergraduate and graduate levels. For example, I have taught communication theory (Washington University ESE 471), transmission and multiplexing (Washington University ESE 571), and signaling and control of communication networks (Washington University ESE 572).

11. I have supervised numerous graduate students, many of whom received a doctoral degree under my guidance. A number of doctoral theses that I have supervised relate specifically to LTE and other cellular technologies. In particular, my students and I have published a number of peer-reviewed articles on resource allocation, scheduling, modulation, mobility management, and multiplexing. Several of these articles received accolades in the field. For example, in 2011, we received a best paper award in 3G WCDMA-related mobility and resource management at the prestigious Mobility 2011 international conference.

12. In addition to my responsibilities as a university faculty member, I have founded two companies. In May 1997, I founded MinMax Technologies, Inc., a fabless semiconductor company that developed switch fabric integrated circuit chips for the Internet. In March 1999, I founded Erlang Technology, Inc., a fabless semiconductor company that focused on the design and development of integrated circuit chips and software for the Internet. One of Erlang's products received a best product of the year award in 2004 from a major trade journal for the electronics industry.

13. Outside my own start-up companies, I have also served in various technology and business advisor roles for other companies and organizations around the world. I was the main technical author for one of two winning proposals to the Korean government for CDMA wireless service licenses (1996). I was responsible

for designing a commercial scale IS-95 CDMA cellular network, which I understand to be one of the earliest such networks deployed in the world. I worked with numerous engineers and scientists around the world to implement this commercial-scale cellular network before IS-95 CDMA was widely accepted. This provided me with extensive insight into various components of CDMA technology, which by and large are used in WCDMA network. I have also been involved in a semiconductor company that specializes in semiconductor memories such as flash EEPROMs as a board member and as a technical advisor (2007-2011).

14. I am a named inventor on eleven U.S. patents, many of which are directly related to resource allocation, packet processing, and network designing. I have extensively published technical papers in international conferences and journals, technical memoranda and reports, and given a number of seminars and invited talks. Many of these papers are specifically within the context of the 3GPP standard. I have organized several international conferences and served as an international journal editor.

15. I am a member of and have been actively involved in a number of professional organizations. For example, I have served as the Chair of the Saint Louis Section of the IEEE with more than 3,000 members (2014), and a member of the Eta Kappa Nu Honor Society for electrical engineers. I have also been an Ambassador of the McDonnell International Scholars Academy (2007-2013).

16. In my nearly 30 years of experience with telecommunications technology, I have acquired significant knowledge about telecommunications systems industry standards, standard setting organizations such as 3GPP, and the rules and document policies that those organizations have in place to develop industry standards.

III. LEGAL STANDARDS

17. In forming my opinions and considering the subject matter of the '268 patent and its claims in light of the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is summarized below.

18. I understand that the claims define the invention. I also understand that an unpatentability analysis is a two-step process. First, the claims of the patent are construed to determine their meaning and scope. Second, after the claims are construed, the content of the prior art is compared to the construed claims.

19. I understand that a claimed invention is only patentable when it is new, useful, and non-obvious in light of the “prior art.” That is, the invention, as defined by the claims of the patent, must not be anticipated or rendered obvious by the prior art.

A. Claim Construction

20. I understand that the United States Patent and Trademark Office

interprets claim terms in an *inter-partes* review proceeding under the same claim construction standard that is used in a United States federal court. I understand that under this standard, the meaning of claim terms is considered from the viewpoint of one of ordinary skill in the art at the time of the alleged invention.

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

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

B. Anticipation Under 35 U.S.C. § 102

23. I understand that under 35 U.S.C. § 102, a patent claim is invalid if its subject matter was patented or described in a printed publication before the effective filing date of the claimed invention. I have been told that this is referred to as invalidity by anticipation. I have been told that a patent claim is anticipated under § 102 if a single prior art reference discloses all limitations of the claimed invention.

C. Obviousness Under 35 U.S.C. § 103

24. I understand that a patent claim is invalid as obvious if the claimed invention would have been obvious to a person of ordinary skill in the art (“POSITA”) at the time the claimed invention was made. This means that even if all of the elements of the claim cannot be found in a single prior art reference that would anticipate the claim, a person of ordinary skill in the field who knew about all the prior art would have come up with the claimed invention. I understand that in an obviousness determination, the person of ordinary skill in the art is presumed to have knowledge of all material prior art. I understand that whether a claim is obvious is based upon the determination of several factual issues.

25. I understand that obviousness is a determination of law based on underlying determinations of fact. I understand that these factual determinations include the scope and content of the prior art, the level of ordinary skill in the art, the differences between the claimed invention and the prior art, and secondary considerations of non-obviousness.

26. In considering obviousness, I understand that one must determine the scope and content of the prior art. I understand that, in order to be considered as prior art to a patent being considered, a prior art reference must be reasonably related to the claimed invention of that patent. A reference is reasonably related if it is in the same field as the claimed invention or is from another field to which a person of

ordinary skill in the art would look to solve a known problem.

27. I understand that one must determine what differences, if any, existed between the claimed invention and the prior art.

28. I understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. In evaluating whether such a claim would have been obvious, one may consider whether a reason has been identified that would have prompted a person of ordinary skill in the art to combine the elements or concepts from the prior art in the same way as in the claimed invention. There is no single way to define the line between true inventiveness on the one hand (which is patentable) and the application of common sense and ordinary skill to solve a problem on the other hand (which is not patentable). For example, market forces or other design incentives may be what precipitated a change, rather than true inventiveness.

29. I understand that whether a prior art reference renders a patent claim unpatentable as obvious is determined from the perspective of a person of ordinary skill in the art at the time of the alleged invention. I have been told that there is no requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, but a suggestion to combine known elements to achieve the claimed invention may come from the prior art, as filtered through the knowledge of one skilled in the art. In addition, I have been told that the

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

30. I understand that there is no rigid rule that a reference or combination of references must contain a “teaching, suggestion, or motivation” to combine references. But I also understand that the “teaching, suggestion, or motivation” test can be a useful guide in establishing a rationale for combining elements of the prior art. I have been told that this test poses the question as to whether there is an express or implied teaching, suggestion, or motivation to combine prior art elements in a way that realizes the claimed invention, and that it seeks to counter impermissible hindsight analysis.

31. I understand that one may consider, e.g., whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; (3) the claimed innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order

to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results; or (7) known work in the field may have prompted variations of use of the same inventions in the same or different fields due to market forces or design incentives that would have been predictable to a person of ordinary skill in the art.

32. I understand that any assertion of secondary considerations of non-obviousness must be accompanied by a nexus between the merits of the invention and the evidence offered.

IV. THE '703 PATENT

A. Background Technology

33. I first begin with a summary of the technology involved with the '703 patent. In describing some of the basic concepts, I refer to a well-known text regarding wireless communications by Sergio Verdú: "Computational Complexity of Optimum Multiuser Detection," *Algorithmica* (1989) (Ex. 1011).

34. The '703 patent relates to multi-user detection, or "MUD." MUD techniques have been known for decades, and documented since at least the 1980s. Generally speaking, a MUD system allows users to transmit information over a shared communication path or channel. The users' information is transmitted as interfering signals over the shared communication path or channel. Interfering signals are signals that suffer from interference from another signal that overlaps in

phase, frequency, time, or power. Interfering signals may include unwanted noise or intentionally overlapping signals from multiple users. Interference in a received signal causes the primary signal's parameters to be obscured by the interfering signals. As these signals are interfering, the receiver of the signals must differentiate the signals to correlate them with each user. MUD detects the signals for each user by demodulating the interfering signals using signal parameters (*e.g.*, signal phase, power, time delay, frequency, or code) related to each user. Of importance in the multiuser detection problem is that unlike the conventional multiple access mechanism, where the signals from different users are separated by the use of orthogonal channels, in the multiuser detection problem, the signals from different users cannot be separated individually, and must be decoded jointly.

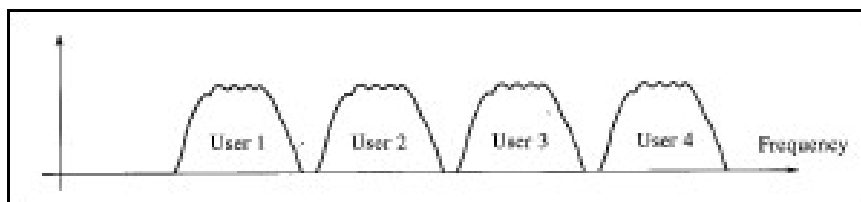
35. MUD is described by Sergio Verdu in "Computational Complexity of Optimum Multiuser Detection," *Algorithmica* (1989) (Ex. 1011). In 1989, MUD was well known as detecting signals for each user in a multi-user system. For example, one implementation of MUD was described as "[t]he optimum multiuser receiver can be viewed as a bank of single-user detectors followed by a common algorithm that selects the most likely transmitted symbols." *Id.*, 304.

36. MUD has been used in many familiar wireless technologies that require sending multiple user data streams over a single signal. Indeed, since the 1980s, multiuser detection has been implemented in cellular networks, satellite

communication, high-speed data transmission lines, digital radio/television broadcasting, fixed wireless local loops, and multitrack magnetic recording. All of these communication systems are subject to multiaccess interference and need a detector to determine the user for the data transmitted on the shared network. Ex. 1012, xix.

37. For example, Qualcomm pioneered the use of Code-Division Multiple-Access (“CDMA”) technology in the 1990s. In the CDMA cellular networks, multi-user detection was implemented by modulating each user’s transmitted signal using a signature waveform to identify the data that belonged to each user in the network. *Id.*

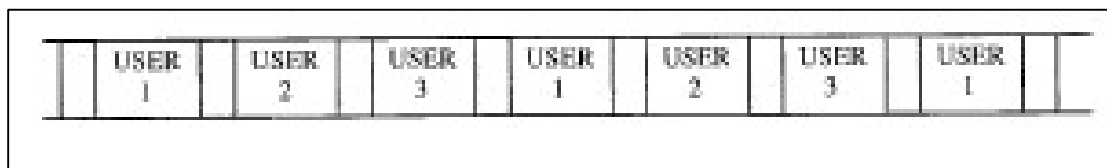
38. Another system pioneered by Qualcomm in the 1990s was Frequency Division Multiplexing or Frequency Division Multiple Access (“FDMA”). In FDMA systems, a different carrier frequency is assigned to each user in a network with a shared communication channel so that the resulting signals and spectra do not overlap. *Id.* This is shown below:



39. As shown in the above figure, each user has a signal parameter based on carrier frequency. The receiver can use this carrier frequency to demodulate the signal and correlate it to the user.

40. Yet another system in use in the 1990s was Time Division Multiplexing (“TDMA”) systems. In such systems, *time* is partitioned into slots assigned to each incoming digital stream in round-robin fashion and demultiplexing is carried out by simply switching on to the received signal at the appropriate times. Time division can be used not only to multiplex collocated message sources but also by geographically separated users who have the ability to maintain time-synchronism.

This is shown below:



41. As shown in the above figure, each user has a signal parameter based on time division. The receiver can use this time division to demodulate the signal and correlate it to the user.

42. Above I referred to Verdu’s paper on optimal multiuser detection. Optimum multiuser detectors were not practical in many real-world systems. By the 1990s, researchers had developed a number of alternatives that were “suboptimal,” but “feasible to implement.” Ex. 1013 at 126. Two such technologies include linear

multi-user detectors and subtractive interference cancellation detectors. Ex. 1013 at 126. Subtractive interference cancellation is particularly relevant to the '703 patent and the prior art discussed in this Declaration.

43. In subtractive interference cancellation, the multi-user detector estimates the interference from each user on the channel, and then attempts to subtract out that interference from other users' signals. MUD using subtractive interference cancellation is often implemented to iteratively, and the detection improves with each iteration. Two varieties of subtractive interference cancellation are in successive interference cancellation, where in each iteration one additional user's interference is subtracted from the received signal; and parallel interference cancellation, where the MUD attempts to estimate and subtract interference from each user in parallel.

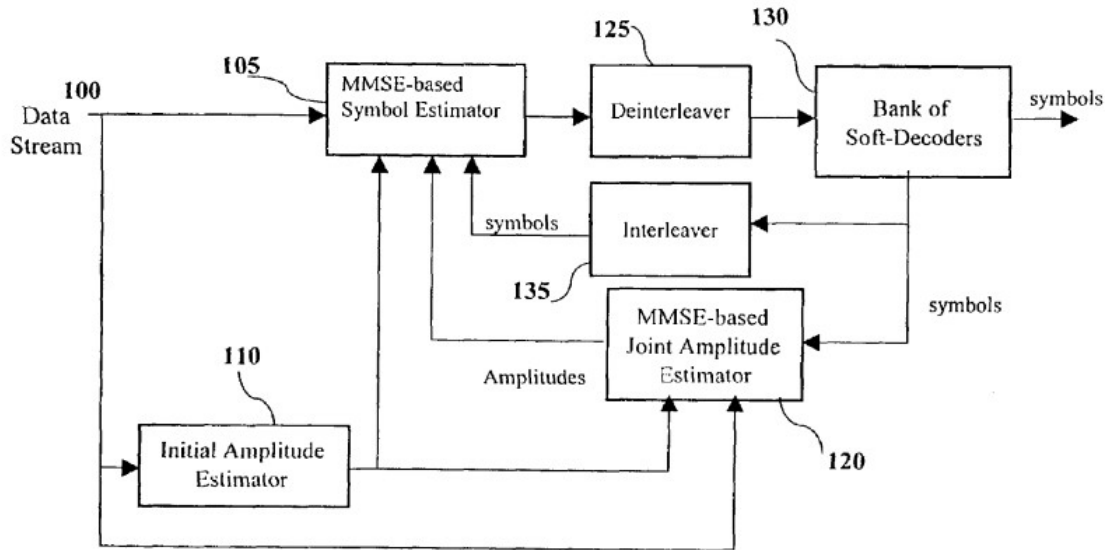
B. Overview of the '703 patent

44. The '703 patent is directed to "co-channel communications" and "increasing capacity by allowing interfering channels"—*i.e.*, multi-user detection. Ex. 1001, 1:24-27. The patent also indicates that it is related to several applications directed to multi-user detection systems. *Id.*, 1:9-18.

45. The '703 patent does not purport to invent MUD. Rather, it explains the prior art "describe[s] ... multiple user systems" where communications "are processed by a multi-user detector." *Id.*, 5:8-11. The patent notes that "[t]here are

various multiuser detectors in the art.” *Id.*, 6:19-25. However, it identifies various disadvantages to existing multi-user detection schemes. For example, the ’703 patent states that some linear multi-user detectors “suffer[] from a significant disadvantage in that [they] require[] knowledge of all parameters to perform processing.” *Id.*, 6:25-34. “Optimal MUD based on the maximum likelihood sequence estimator” is criticized because it is “computationally complex” and “not possible to accomplish in a real-time environment.” *Id.*, 6:35-43. “There are several suboptimal multiuser detectors that are less computationally complex and known in the art,” but the ’703 patent claims they “fail[] or cases of overloaded multiple access systems,” *e.g.*, “where the number of users is doubled or tripled relative to the existing state of the art.” *Id.*, 6:54-7:5. In sum, the ’703 asserts that “the optimum maximum likelihood multi-user detector ... require[s] too many computations to keep up with real time transmissions,” while “a fast, but inferior, multiuser detection scheme causes poor quality output when there many interferers or users.” *Id.*, 8:17-27.

46. The ’703 patent claims to invent a multi-user detection system that “provid[es] high quality real-time processing for multiple access systems, including overloaded situation.” Ex. 1001, 11:33-37. Figure 2 shows a “block diagram perspective ... for one embodiment of the invention.” *Id.*, 11:18-20.



47. In Figure 2, Data Stream 100 is communicated to MMSE-based Symbol Estimator 105. “[O]ther forms of symbol estimators ... are within the scope of the invention.” Ex. 1001, 14:58-15:3. The ’703 patent suggests some known MUD techniques for the symbol estimator, including “linear detectors, ... maximum likelihood; decorrelating decision-feedback detector; ... successive interference cancellation (SIC), [and] parallel interference cancellation (PIC) or multi-stage detector.” *Id.*, 15:53-65.

48. The received signal is also passed to an initial amplitude estimator and a joint amplitude estimator. *Id.*, 15:26-29. The symbol estimator “uses the initial amplitude estimate only on the first iteration,” and “for all other iterations it uses the amplitude estimates from the ... Joint Amplitude Estimator.” *Id.*, 15:47-51.

49. Symbol estimates are provided to “a bank of single user decoders,” which output “symbol estimates and their respective likelihoods.” *Id.*, 16:3-6, 16:18-20. The estimates are iteratively “fed back around” to the symbol estimator and the joint amplitude estimator. *Id.*, 16:20-23. In each each iteration, “[t]he new symbol likelihoods from the decoders 130 are used to update previous amplitude estimates in the joint amplitude estimator 120.” *Id.*, 16:38-40. The symbol estimator “re-estimates the symbols based on prior information on the symbols and the updated parameter estimates.” *Id.*, 16:43-47. The process “repeat[s] for some fixed number of iterations or until the estimates of the bit error rate or frame error rate achieve some desired level.” *Id.*, 16:49-51.

C. Prosecution History of the '703 patent

50. I have reviewed the prosecution history of the application that led to the '703 patent. Ex. 1002. I have provided a summary below of the prosecution history.

51. The application that led to the '703 patent was filed on April 19, 2005, and claimed priority back to a provisional application filed on April 14, 2003. Based on my review, there were no substantive rejections or amendments before the claims were issued. *See generally* Ex. 1002.

D. Person of Ordinary Skill in the Art

52. I am informed that patentability must be analyzed from the perspective of “one of ordinary skill in the art” in the same field as the '703 patent at the time of

the invention. As previously discussed, the relevant time of invention is the patent's priority date, which is no earlier than April 14, 2003. Moreover, I understand that whether or not a patent application provides "written description" support for patent claims must also be assessed from the perspective of a person of ordinary skill in the art.

53. I am also informed that several factors are considered in assessing the level of ordinary skill in the art, including (1) the types of problems encountered in the art; (2) the prior art solutions to those problems; (3) the rapidity with which innovations are made; (4) the sophistication of the technology; and (5) the education level of active workers in the field.

54. A person of ordinary skill in the art pertinent to the '703 patent would have had at least a bachelor's in EE/CE/CS, physics, or equivalent, and two years of experience with cellular telecommunications, radio-access network architectures, protocols, and signal propagation in wireless networks. Additional education could substitute for professional experience and vice versa. A person of ordinary skill in the art would also be able to understand and apply the prior art discussed herein.

55. Although I surpass this definition of one of ordinary skill in the art now and at the priority date of the '703 patent, my analysis regarding the '703 patent has been based on the perspective of one ordinary skill in the art as of the priority date of the '703 patent.

56. I am also familiar with the knowledge of the person of ordinary skill in the art as of the priority date of the '703 patent. I am able to opine on how the person of ordinary skill in the art would have understood the disclosure and claims of the '703 patent, the disclosures of the prior art, the motivation to combine the prior art, and what combinations would have been obvious to one of ordinary skill in the art.

V. CLAIM CONSTRUCTION OF TERMS OF THE '703 PATENT

57. As I discussed above, I have been informed that for purposes of *inter-partes* reviews, the standard for claim construction of terms within the claims of the patent is the same as that applied in federal district court litigation. I have been asked to assume that the claim terms otherwise have their plain and ordinary meaning to a person skilled in the art in light of the specification and the prosecution history.

58. As of this time, I am not aware of any term that requires specific construction for my opinions. To the extent Patent Owner suggests a narrow construction for a term, I reserve the right to respond to those opinions.

VI. OVERVIEW OF PRIOR ART

59. Below, I discuss the references I rely on in my declaration.

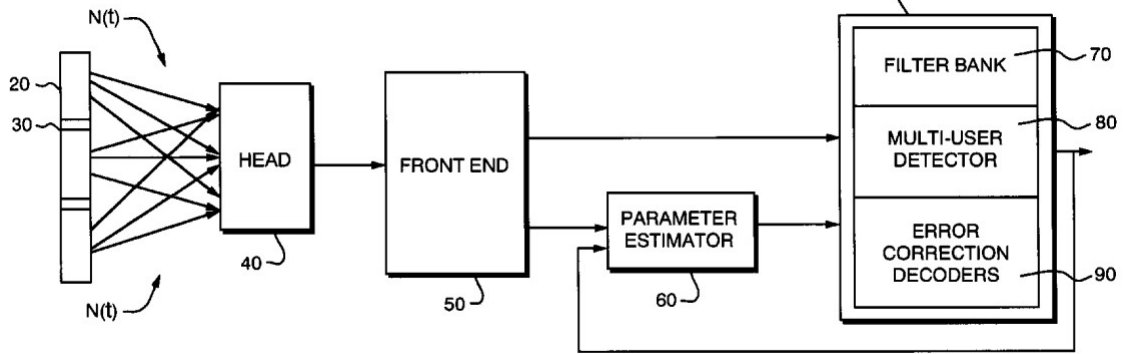
A. Brommer

60. U.S. Pat. Pub. No. 2004/0037202 ("Brommer") (Ex. 1004) claims priority to a U.S. patent application filed on August 26, 2002, published on February

26, 2004, and issued on November 30, 2004. *See* Ex. 1004. I understand Brommer is prior art.

61. Brommer discloses a “processing scheme for digital storage media using multi-user detection to separate tracks of data or remove interference from neighboring tracks.” *Id.*, Abstract. Brommer discloses an iterative process for multi-user detection, generating initial estimates for each track, and refining those initial estimates using a feedback loop. *Id.*, 15:20-35, 26:1-14.

62. Figure 1 of Brommer illustrates one embodiment of Brommer’s multi-user detector. In Figure 1, “digitized signals are processed by a parameter estimator 60 and are also processed by a MUD processing Section 65.” *Id.*, 15:24-26. The parameter estimator identifies “track transfer function[s],” including “amplitude” information, for each user in the received data stream. *Id.*, 12:57-59, 13:5-8. The “multi-user detector 80 uses an algorithm to establish estimates for the most probable digital bits and a bank of decoders 90 provides further processing.” *Id.* at 15:28-31. “The data generally loops within the MUD section until a fixed number of iterations is satisfied or a certain level of accuracy is achieved.” *Id.* at 15:31-33.



63. Brommer's Figure 8 also describes the system in terms of a "synchronizer 715" that "generates a track transfer function for each of the appropriate functions . . . , including estimates of the pulse envelope [e.g., amplitudes] for each track." *Id.*, 25:64-67, 26:52-53. A joint detector generates preliminary code estimates, and a code processor generates final symbol estimates. *Id.*, 26:1-9. The joint detector also provides updated parameter estimates to the synchronizer. *Id.*, 26:1-4. The system "[i]terat[es] between the code processor and the joint detector . . . to refine these estimates in a methodical way." *Id.*, 26:9-12.

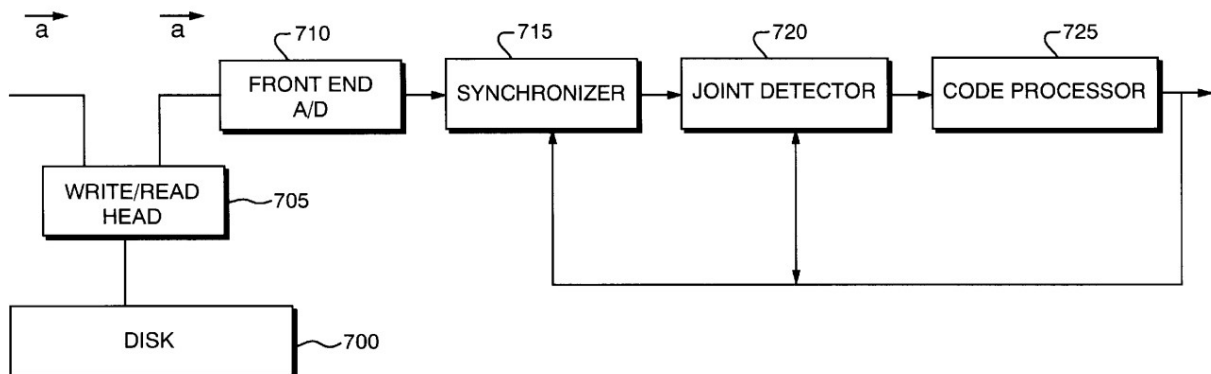


FIG. 8

B. Learned

64. U.S. Patent No. 7,190,743 (“Learned”) (Ex. 1005) was filed July 29, 2002, and published January 29, 2004. *See* Ex. 1005. I understand that Learned is prior art.

65. Learned discloses a method and apparatus for optimizing tree pruning in a multiuser detector. Ex. 1005, Abstract, 1:13-15. Learned’s multi-user decoder assigns interfering users to levels of a decoding tree in the decoder, with signals being assigned to different levels of the tree based on their signal strength (*i.e.*, energy or power level). *Id.*, Abstract, 4:60-67. In the embodiment illustrated in Figure 4, the power level of each user signal is determined by a “user information assembler unit 12 which receives its information from parameter estimation unit 11.” *Id.*, 10:35-39. The MUD receives the “power order information, as well as all other parameter values for each detected user, ... from user information assembler unit 12,” and uses it to “build its decoding tree by assigning the indices of active users within a symbol interval according to the power level of each received signal.” *Id.*, 11:14-22. The embodiment in Figure 4 is designed to be used with a prior art “turbo multi-user detector performing iterative turbo decoding to separate multiple interfering signals on the same communication channel.” *Id.*, 5:34-40.

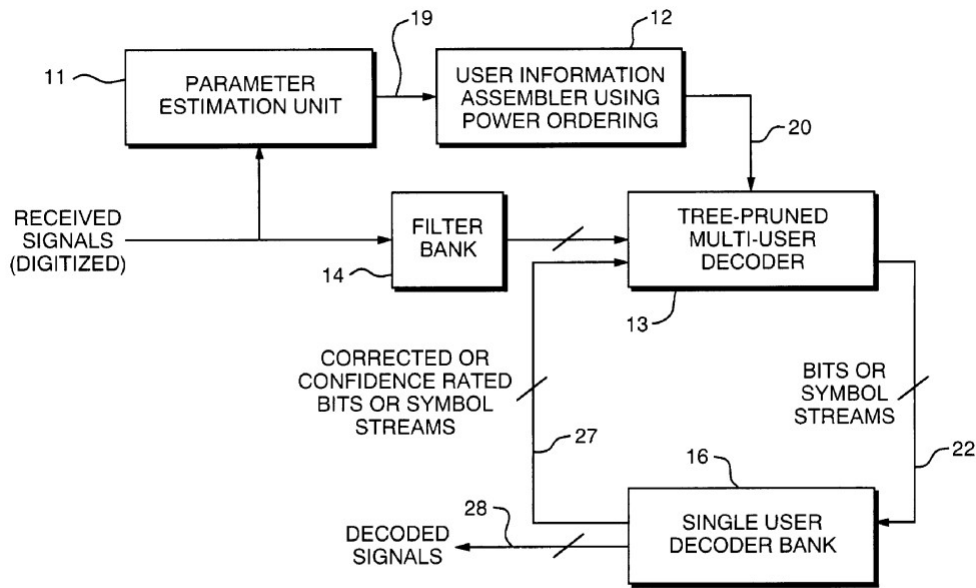


FIG. 4

C. Frank

66. U.S. Patent Pub No. 2003/0035469 (“Frank”) (Ex. 1006) was filed on August 20, 2001 and published on February 20, 2003. *See* Ex. 1006. I understand that Frank is prior art.

67. Frank is directed to “receivers for code division multiple access (CDMA) communication systems, and more particularly, ... receivers having linear, minimum mean square error equalization with successive or parallel interference cancellation for mobile communication forward links.” Ex. 1006, [0001].

68. Frank discloses a system for interference cancellation, using both an amplitude estimator and a transmitted signal estimator as part of a feedback loop. Frank’s system is illustrated in connection with Fig. 1, which shows a receiver with

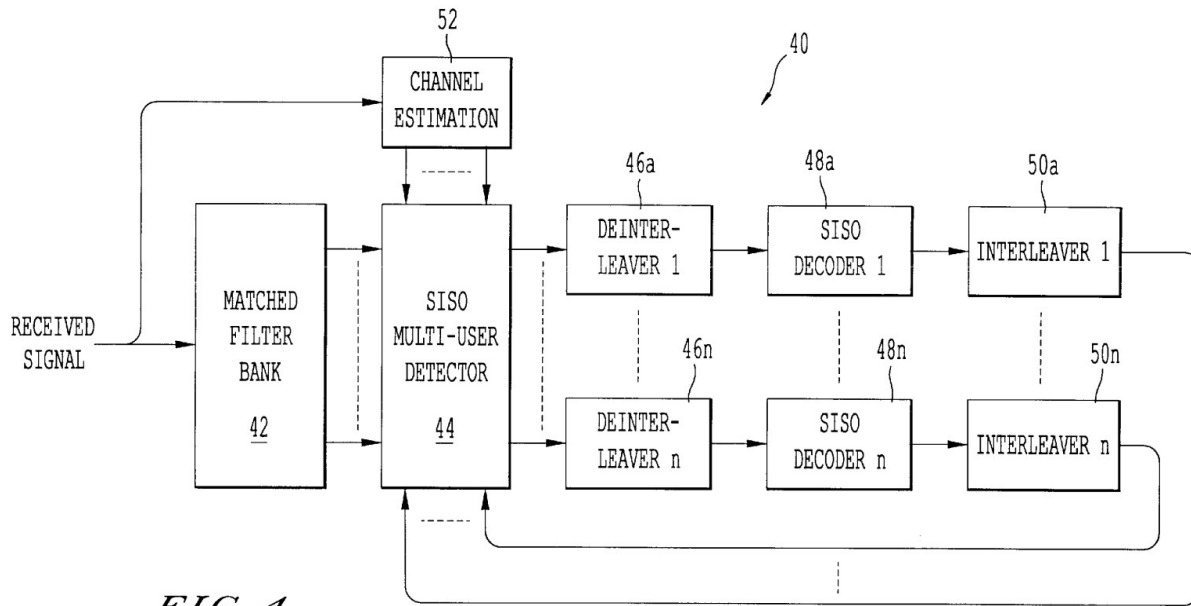
69. U.S. Pat. No. 5,905,946 (“Lilleberg”) (Ex. 1007) issued on May 18, 2000. *See* Ex. 1007. I understand that Lilleberg is prior art.

Samsung Ex. 1003

E. ElGamal

71. U.S. Patent No. 6,898,248 (“ElGamal”) claims priority to a U.S. provisional application filed on July 12, 1999, and issued on May 24, 2005. *See* Ex. 1008. I understand that ElGamal is prior art.

72. ElGamal discloses a “receiver ... for multi-user reception using an iterative, soft input / soft-output (SISO) multi-user detection algorithm.” Ex. 1008, Abstract. ElGamal’s system includes “multi-user detection and decoding in a multiple antenna wireless communication system.” *Id.*, 1:24-27. Figure 4 of ElGamal, reproduced below, illustrates one embodiment of the iterative receiver. In this embodiment, an “estimation module” provides channel estimates (*e.g.*, amplitude) for each user, and a “soft-input/soft-output (SISO) multi-user detector module 44 provides joint soft-decision estimates of the n streams of data.” *Id.*, 9:8-12. Each user’s data stream is “decoded by the separate SISO channel decoders ... associated with the component channel codes.” *Id.*, 9:12-14. In each iteration, “the soft outputs from the channel decoders 48a through 48n are used to refine the processing performed by the SISO multi-user detector.” *Id.*, 9:18-21.



73. ElGamal explains that the SISO channel decoders “can employ any of the following algorithms: (1) the maximum a-posteriori (MAP) approach, which is optimal in the sense that it minimizes the probability of bit error at the decoder output; (2) the (log-MAP) approach, which is a lower complexity, additive version of the (MAP) rule that operates in the log-domain; or (3) the soft output Viterbi algorithm (SOVA).” *Id.*, 9:26-33.

F. Hottinen

74. U.S. Pat. No. 5,995,499 (“Hottinen”) (Ex. 1009) issued on November 30, 1999. *See* Ex. 1009. I understand that Hottinen is prior art.

75. Hottinen discloses a “signal detection method” for a “mobile system with co-channel interference.” Ex. 1009, Abstract. Hottinen recognizes that “channel estimation ... performed in the presence of other co-channel signals” will

“severely degrade the reliability of the channel estimation due to cross correlation interference.” *Id.*, 3:23-31. Hottinen teaches that “joint channel estimation” can be used to “clean[]” signals “of interference by estimating the channel of the interferer, regenerating this interfering signal ... and subtracting the regenerated signal from the received signal.” *Id.*, 3:65-4:3. “Each iteration stage produces a slightly better channel estimate and data detection.” *Id.*, 4:6-7.

G. Zha

76. “Soft-Decision Successive Interference Cancellation CDMA Receiver with Amplitude Averaging and Robust to Timing Errors” by Zha *et al.* (“Zha”) (Ex. 1010) is a paper that was presented at the IEEE Global Telecommunications Conference 2001 (GLOBECOM '01), which took place between November 25 and 29, and was published in the corresponding conference proceedings. I understand that Zha is prior art.

77. It is my opinion that Zha was publicly available by no 2001, and no later than August 2002. I am familiar with the IEEE's publication practices, having served in multiple positions in the Saint Louis Section of the IEEE and on multiple IEEE committees, having served as a reviewer for multiple IEEE journals and publications, having participated in many IEEE conferences, and having published in many IEEE journals. The IEEE is a well-known and very reputable publisher of scientific and technical articles. The copyright dates indicated on the face of an

IEEE-published paper is a strongly reliable indicator of its publication date and public availability. In this case, Zha indicates on its face that it was published in 2001.

78. I also note that Zha is listed on the IEEE Xplore website at <https://ieeexplore.ieee.org/document/965517>, with a date of publication on IEEE Xplore of August 6, 2002. A POSITA would consider the IEEE Xplore website as a highly reliable indicator of the publication date of a paper. In my opinion, Zha is also a complete, true, and correct copy, since it is identical to the copy available on IEEE Xplore. Based on my review, Zha is complete and has no visible alterations. A POSITA would expect an IEEE-published paper to appear in the IEEE Xplore database. Zha also has all the hallmarks of an authentic copy of an IEEE paper, including the IEEE markings at the bottom of the first page, a stylized title, author information (including affiliations), and the organization of the paper.

79. Zha discloses a “multiuser detection method” using “successive interference cancellation (SIC).” Ex. 1010, 743. Zha explains that it was known as early as 1994 that “amplitude averaging over M bits can result in a significant performance improvement over no averaging for the SIC receiver.” *Id.* (citing reference [3], a 1994 paper). Specifically, “amplitude estimation by averaging over M bits can reduce the noise variance by an order of M ,” which “results in a significant

BER [bit error rate] performance improvement over a linear SIC receiver which does not use amplitude averaging.” *Id.*, 744.

80. Zha proposes an improved multiuser detector that incorporates amplitude averaging. *Id.*, 743. The detector has “multiple interference cancellation stages.” *Id.*, 744. In each stage after the first, each “user’s received signal is estimated by subtracting other users’ regenerated signals from the [combined] received signal”; the “averaged amplitude estimate” is then obtained “by averaging the instantaneous estimate of” a particular user’s “amplitudes over a block of M bits”; and symbol estimates are then estimated and “normalized with respect to the averaged amplitude” to determine a “data bit decision.” *Id.* The data bit decision uses a “soft bit decision rule.” *Id.* The algorithm “is terminated after a desired number of interference cancellation stages.” *Id.*

VII. SUMMARY OF OPINIONS ON UNPATENTABILITY

81. In the analysis that follows, I identify the following combinations of prior art that, in my opinion, anticipate and/or render obvious the ’703 patent claims:

Ground	Basis	Reference(s)	Claims
1	§103	Brommer, Lilleberg and Hottinen	1-3
2	§103	Brommer, Lilleberg, Hottinen, and Learned	4
3	§103	Brommer, Lilleberg, Hottinen, and ElGamal	5
4	§103	Frank and Zha	1-3, 5
5	§103	Frank, Zha, and Learned	4

A. Ground 1: Claims 1-3 are Rendered Obvious by Brommer in view of Lilleberg and Hottinen

82. I provide a summary of this ground as follows. Brommer discloses an apparatus for reading data using a multi-user detector algorithm in an iterative (feedback) loop that processes a multi-user signal and generates estimates for the most probable digital bits for each individual signal. Brommer uses a track transfer function to determine parameters, including amplitude, that may be used to distinguish individual data signals within the multi-user signal. Lilleberg also discloses a multi-user detection scheme, but specifically describes an improved parameter estimation technique that separately performs a preliminary estimate of parameters (including amplitude), and then updates the parameter estimates to increase accuracy. Hottinen teaches a joint channel estimation method for eliminating co-channel interference. In my opinion, it would have been obvious to a POSITA to apply Lilleberg's teachings regarding preliminary and updated parameter estimates and Hottinen's joint channel estimation method to Brommer's system, as I explain below.

1. Motivation to Combine and Reasonable Expectation of Success

83. In my opinion, and as I explain below, a POSITA would have been motivated to apply Lilleberg and Hottinen's teachings regarding parameter estimation to Brommer's receiver for processing multi-user signal streams.

84. Although Lilleberg and Hottinen both relate to wireless communication systems, and not a digital media storage system like Brommer, in my opinion Brommer provides a motivation to look to multi-user detection techniques used in other applications, including wireless communication systems, and a POSITA would know to look to such systems to improve Brommer's multi-user detector. Specifically, Brommer states that "[t]here are various modes of MUD processing known in the art, however the implementation in a disk drive scenario has heretofore not been accomplished." Ex. 1004, 15:33-35. Accordingly, in my opinion, a POSITA would have been motivated to look to other "modes" of MUD processing to improve Brommer's implementation, including MUD processing in wireless communication systems.

85. Brommer also expressly suggests looking to other references for parameter estimation techniques, and in my opinion this would have motivated POSITA to look to references such as Lilleberg and Hottinen. Brommer states that the "parameter estimation module ... is not the central issue of this invention, and as such is only briefly described here." Ex. 1004, 26:52-54. Accordingly, in my opinion a POSITA would have been motivated to look outside of Brommer for implementation details and improvements relating to Brommer's parameter estimator.

86. It is my opinion that a POSITA would have been particularly motivated to look to Lilleberg's teachings in order to improve Brommer's parameter estimator because Lilleberg teaches that its "invention relates to a method for estimating a channel" where "the received signal is subjected to *elimination of multiple access interference*," and Brommer's system performs such elimination of interference from multiple tracks of data. Ex. 1007, 1:8-11; *see also* Ex. 1004, Abstract ("Joint detection signal processing resolves the interference and data bits from the multiple sensed tracks."). Lilleberg also teaches that its parameter estimation methods "can be generally applied" in any system "in which elimination of multiple access interference is applied." Ex. 1007, 1:12-14. In my opinion, a POSITA would have known this and would have therefore been particularly motivated to apply Lilleberg's teachings relating to the use of two parameter estimation units because Lilleberg teaches that doing so allows "more accurate estimates [to be] obtained." *Id.*, 3:31-36. A POSITA would also have been motivated to use Lilleberg's teachings because Lilleberg teaches that the use of two parameter estimators is "advantageous" because estimates from the second estimator "can be supplied as feedback to [the] first estimator, where they can be utilized," specifically to improve detection in subsequent iterations by improving the initial estimate. *Id.*, 2:38-42.

87. In my opinion, a POSITA would have further been motivated to use a joint estimator as Lilleberg's second estimation unit in view of Hottinen. As I

explained above, Brommer only “briefly” describes its parameter estimator and explains that that is not the focus of the invention. Ex. 1004, 26:52-54. Lilleberg similarly does not specify a particular parameter estimation method for the “second estimation means,” and instead notes that the “second estimation means ... can be conducted by a known estimation method.” Ex. 1007, 3:36-38. Hottinen discloses that “joint estimation of several co-channel signals is necessary because [when] channel estimation is performed in the presence of other co-channel signals,” “the reliability of the channel estimation” is “severely degrade[d] ... due to cross correlation interference.” Ex. 1009, 3:27-31. Hottinen teaches that its joint channel estimation method can be used to “clean” signals of interference to produce a “better channel estimate and data detection.” *Id.*, 3:63-4:7. Accordingly, in my opinion a POSITA would have understood that Hottinen’s joint estimation method would be particularly beneficial in combination with Brommer and Lilleberg, because both Brommer and Lilleberg are directed to systems affected by co-channel interference.

88. In my opinion, a POSITA would have reasonably expected this combination to succeed. As I explained in Section IV.A, MUD had long been known in the field, and parameter estimation was a well-known step in MUD algorithms. In addition, Lilleberg expressly discloses that its parameter estimation method may be “generally applied” to systems “in which elimination of multiple access interference is applied,” which would include Brommer’s system. Ex. 1007, 1:9-12.

Lilleberg similarly discloses that parameter estimation in its second estimation means “can be conducted by a known estimation method,” which would include Hottinen’s joint estimation method. *Id.*, 3:36-38. In my opinion, a POSITA would have understood at least based on these teachings that Brommer, Lilleberg, and Hottinen are compatible. In my opinion, applying Lilleberg’s and Hottinen’s teachings to Brommer’s system would have been well within the capabilities of a POSITA, and would have only required the application of routine engineering to apply these known techniques to Brommer’s system to achieve predictable results. It is further my opinion that a POSITA would have understood that the references disclose interrelated teachings based on routine technologies and would have been amenable to various well-understood and predictable combinations.

89. Finally, it is my opinion that Brommer, Lilleberg, Hottinen, and the ’703 patent are analogous art because all four are directed to the same field of multi-user detection, that is, processing a data stream from multiple users using joint signal detection techniques. Ex. 1001, 1:24-27 (“The present invention relates to communications and more particularly to co-channel communications, and more particularly to increasing capacity by allowing interfering channels.”), Ex. 1004, 10:62-65 (“it is a general object of the present invention to provide a novel and useful digital recording implementation that uses multi-user detection techniques that can solve the problems described herein”), Ex. 1007, Abstract (“A method for estimating

a channel in a receiver of a cellular radio system ... for subjecting the received signal to elimination of multiple access interference.”); Ex. 1009, 1:9-15 (“The present invention relates to a signal detection method ... in which a primary signal and at least one interfering co-channel signal are received.”).

2. Claim 1

(a) 1[pre]: “An apparatus for processing a digital data stream from multiple users, comprising:”

90. In my opinion, Brommer renders the preamble obvious to the extent it is limiting.

91. Brommer discloses an apparatus that processes a digital data stream from multiple users—*i.e.*, multiple interfering tracks of a storage device. Brommer teaches that “[a]n object of the invention includes an apparatus for reading data bits from a storage medium using multi-user detection, comprising *a plurality of tracks* wherein *the data bits reside within a plurality of storage cells on the tracks.*” Ex. 1004, 12:49-52. The plurality of tracks comprise a digital data stream from multiple users.

92. Brommer describes, in more detail, a “multi-user reading device ... having several tracks,” and a “read element” that “simultaneously extracts a plurality of signals from the tracks.” *Id.*, 15:9-15; *see also id.*, 24:40-50 (“[T]he several track signals are picked up simultaneously.”). The analog signals from the tracks are

“converted to a digital stream of data,” which is then processed using “multi-user detection of the multiple signals.” *Id.*, 25:35-37, 25:48-53.

93. Brommer does not state that different tracks are associated with a different user in a communication network. However, a POSITA would have understood that in the context of the '703 patent, a digital data stream from “multiple users” refers to data from different sources, and does not necessarily require multiple human users or multiple devices on a network. This is consistent with the '703 patent's explanation that “a data stream of multiple users is understood to represent digital data *from a number of references* and not necessarily multiple users in communications.” Ex. 1001, 11:39-42. Each of Brommer's tracks is a separate reference that stores and supplies digital data.

94. Accordingly, Brommer renders obvious this element.

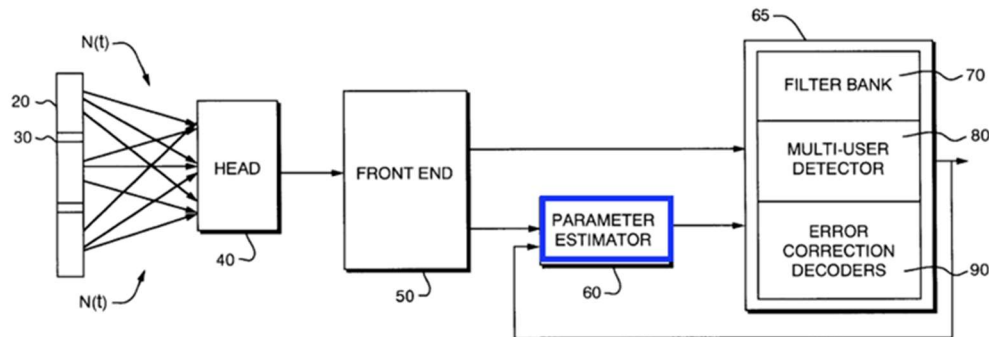
(b) 1[a]: “an initial amplitude estimation unit processing said data stream and producing initial amplitude estimates on a first iteration”

95. In my opinion, Brommer renders obvious this element.

96. Brommer discloses a “parameter estimator.” The “parameter estimator” processes the digital data stream and produces initial amplitude estimates on the first iteration of multi-user detection.

97. Brommer's parameter estimator is shown in Figure 1, annotated below. The parameter estimator receives a digital data stream from a “front end” unit (50)

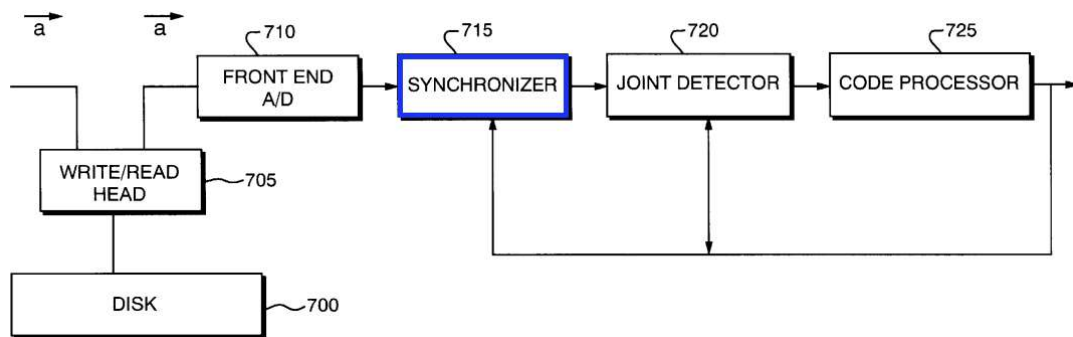
and passes parameter estimates to the “multi-user detector” (80). Brommer explains that the front end unit “process[es] the electrical signals and convert[s] the electrical signals into a plurality of digital bits,” which are a digital data stream. *Id.*, 12:55-57. The parameter estimator receives the digital data stream and “identif[ies] a track transfer function for the plurality of tracks.” *Id.*, 12:57-59. The “track transfer function includes envelope information of a shape, **amplitude** and phase of each of the plurality of data tracks.” *Id.*, 13:5-8.



98. Figure 8, annotated below, provides another view of Brommer’s system with additional details. In my opinion, a POSITA would understand from Figure 8 that the parameter estimator produces **initial** amplitude estimates on a **first iteration** of a multi-user detection algorithm, as I explain below.

99. In Figure 8, the parameter estimator is represented by synchronizer 715. *See* Ex. 1004, 25:54-58 (“The synchronizer [715] derives certain parameters that uniquely distinguish the characteristics of each individual data element or sub-track.”), 26:52-53 (“The parameter estimation module, [is] realized in this disclosure

by the synchronizer 715.”). “The synchronizer 715 generates a track transfer function for each of the appropriate functions and for each data element,” which includes “the mean pulse *amplitude*.” *Id.*, 25:61-67. The parameter estimates from the synchronizer are “known or made available to the joint detector 720.” *Id.*, 26:58-61; *see also id.*, 23:55-58 (“The Multi-User Detector ... uses the envelope, *amplitude* and phase information to differentiate the multiple signals taken from the read head 600.”).



100. In my opinion, a POSITA would have understood that because the data stream passes through the synchronizer for amplitude estimation *before* it is received by the joint detector and code processor, the amplitude estimates will be initial estimates determined at the first iteration of the multi-user detection. In other words, because the synchronizer provides amplitude estimation before joint detection or code processing has occurred, the estimates must, at a minimum, be determined during the first iteration.

101. In addition, even if Brommer did not disclose that its parameter estimator produces initial amplitude estimates, in my opinion it would have been obvious to a POSITA to generate initial amplitude estimates using Brommer's parameter estimator in view of Lilleberg. Lilleberg discloses using two different parameter estimation units: a first unit "where *preliminary* channel estimation is conducted by a known estimation method," and a second unit "whereby more accurate estimates are obtained than in the first estimation means, which conduct the preliminary estimation." Ex. 1007, 3:21-25, 3:31-38. Lilleberg's estimation units estimate "the complex *amplitude* and the delay." *Id.*, 3:25-26.

102. In my opinion, a POSITA would have been motivated to apply Lilleberg's teachings regarding first and second estimation units to Brommer's system, and would have reasonably expected to be successful in doing so, for the reasons I provided in Section VII.A.1 above.

103. Accordingly, Brommer in combination with Lilleberg and Hottinen renders obvious this element.

(c) **1[b]: "a joint amplitude estimator coupled to said data stream and said initial amplitude estimator, wherein said joint amplitude estimator produces updated amplitude estimates"**

104. In my opinion, Brommer renders obvious this element, in combination with Lilleberg and Hottinen.

105. Brommer discloses a “joint detector” that “provides updated symbol phase estimates that are fed back to the synchronizer 715.” Ex. 1004, 26:1-4. Brommer also discloses that the synchronizer and joint detector together perform parameter estimation. *Id.*, 26:27-36.

106. As I discussed above for Limitation 1[a], in my opinion it would have been obvious to a POSITA in view of Lilleberg to provide two estimation units in Brommer’s system—a first estimation unit for generating initial amplitude estimates, and a second estimation unit for producing updated amplitude estimates. Ex. 1007, 3:21-38 (describing “first” and “second” “estimation means” that estimate “complex amplitude,” and the second estimation means produces “more accurate estimates” than the first estimation means).

107. Lilleberg does not describe its second estimation unit as a joint amplitude estimator, and does not require a specific estimation method to be used in the unit (such as joint amplitude estimation). However, in my opinion it would have been obvious to a POSITA in view of Hottinen to use joint estimation for Lilleberg’s second estimation means. Lilleberg teaches that its estimation method can be used “with any channel estimation algorithm.” Ex. 1007, 2:34-35; *see also id.*, 3:36-38 (“Also in the second estimation means the estimation can be conducted by a known estimation method.”). Hottinen discloses “joint estimation of several co-channel

signals.” Ex. 1009, 3:24-38; *see also id.*, 5:56-7:8 (describing the “joint channel estimation method of several co-channel signals according to the invention”).

108. In my opinion, a POSITA would have been motivated to apply Lilleberg’s teachings regarding first and second estimation means to Brommer’s system, and to further use a joint channel estimation method as taught by Hottinen for Lilleberg’s second estimation means, and would have reasonably expected to be successful in doing so, for the reasons I provide above in Section VII.A.1.

109. In the combination of Brommer, Lilleberg, and Hottinen, Lilleberg’s second estimation means, implementing a joint estimation method as taught by Hottinen, would be coupled to Brommer’s data stream. That is because Lilleberg teaches that after initial interference cancellation, “the received transmission” (which is the data stream) “is supplied to a second estimation means” where “the channel parameters are re-estimated.” Ex. 1007, 4:1-9. This aspect of Lilleberg is consistent with the ’703 patent specification, which explains that before the data stream arrives at the joint amplitude estimator (illustrated in Figure 4), “interference cancellation is performed.” Ex. 1001, 19:47-51.

110. In the combination of Brommer, Lilleberg, and Hottinen, Lilleberg’s second estimation means would also be coupled to Brommer’s parameter estimator or synchronizer according to Lilleberg’s teachings. Lilleberg expressly teaches “utiliz[ing] feedback ... from the second estimation means ... to the first estimation

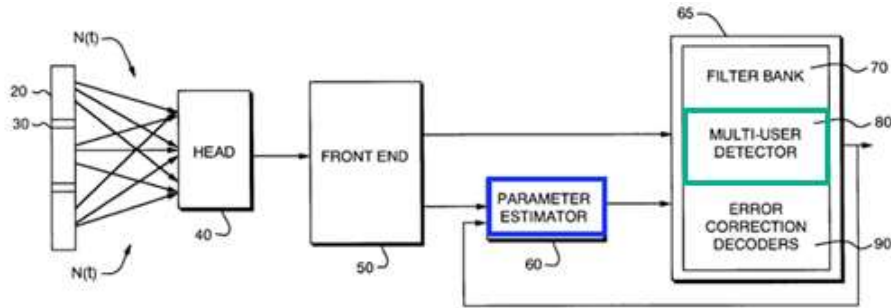
means” so that the first estimation means can use “the channel parameters obtained from the second estimation means” to produce estimates for subsequent samples of a received signal. Ex. 1007, 3:39-47. Thus, coupling the second estimation means to Brommer’s parameter estimator or synchronizer would improve the amplitude estimates for subsequent samples of data.

111. Accordingly, Brommer in combination with Lilleberg and Hottinen renders obvious this element.

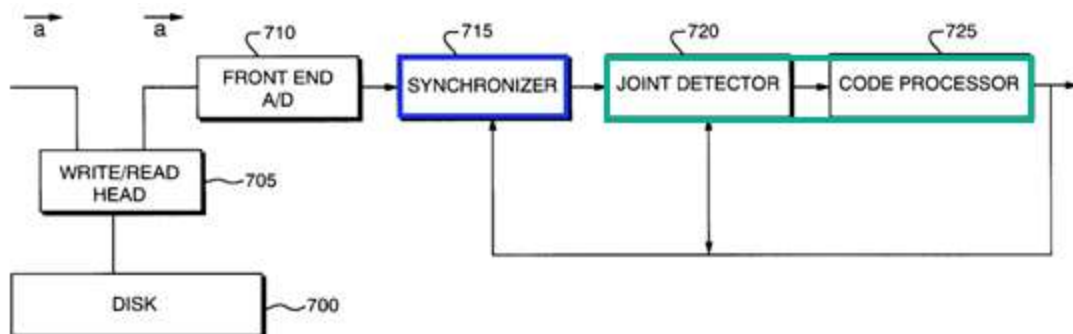
(d) 1[c]: “a symbol estimator coupled to said data stream, said initial amplitude estimator, and said joint amplitude estimator, wherein said symbol estimator produces a plurality of symbols estimates for each user; and”

112. In my opinion, Brommer, Lilleberg, and Hottinen render obvious this limitation.

113. Brommer discloses a multi-user detector that determines symbol estimates by “us[ing] an algorithm to establish estimates for the most probable digital bits.” Ex. 1004, 15:28-29. As shown in Figure 1, annotated below, the multi-user detector is coupled to Brommer’s data stream, which is received via the front end unit, and to Brommer’s parameter estimator which provides initial amplitude estimates (as described above). *Id.*, Fig. 1.



114. These elements are also represented in Figure 8. In Figure 8, the multi-user detector is implemented using a joint detector and code processor, which make “preliminary estimates of the interfering digital signal values contained in the received signal” (joint detector) and “update the preliminary estimates” using “properties of the data encoding” (code processor), thereby producing multiple symbol estimates for each user. Ex. 1004, 26:1-9. The joint detector and code processor are coupled to the synchronizer (which provides initial amplitude estimates) as shown in Figure 8, and to the received signal, as discussed above.



115. In both examples, the multi-user detector produces symbol estimates for each user iteratively. *Id.*, 15:31-33 (“The data generally loops within the MUD section until a fixed number of iterations is satisfied or a certain level of accuracy is

achieved.”), 26:9-14 (“Iteration between the code processor and the joint detector 720 is often performed to refine these estimates in a methodical way,” using an “iterative processing or turbo MUD algorithm.”). Accordingly, in my opinion a POSITA would have understood that across the plurality of iterations, a plurality of symbol estimates will be produced for each user.

116. As I explain above in the context of Limitation 1[b], in the combination of Brommer, Lilleberg, and Hottinen, the second estimation means taught by Lilleberg (applying a joint estimation method as taught by Hottinen) would be added to Brommer’s system and coupled to Brommer’s parameter estimator/synchronizer. Similarly, in the combined system, Lilleberg’s second estimation means would be coupled to the Brommer’s multi-user detector, or joint detector and code processor. That is because Brommer teaches that “it is well known in the art how to compute parameter estimates,” and these estimates are “known or made available to the joint detector.” Ex. 1004, 26:28-61. Lilleberg similarly teaches that the channel estimates from its second estimation means are provided to a “detector,” and that the detector generates “preliminary symbol estimates.” Ex. 1007, 3:27-29, 4:4-16. As discussed above, in my opinion, a POSITA would have been motivated to combine the references with a reasonable expectation of success.

117. Accordingly, in my opinion, Brommer in view of Hottinen and Lilleberg renders obvious this element.

- (e) **1[d]: “a bank of decoders coupled to said symbol estimator, producing a plurality of symbol likelihood estimates for each user, wherein said symbol likelihood estimates are iteratively fed back to said symbol estimator and said joint amplitude estimator until a final condition is obtained.”**

118. In my opinion, Brommer, in combination with Lilleberg and Hottinen, renders obvious this element.

119. Brommer discloses a “bank of decoders 90.” Ex. 1004, 15:28-30. As shown in Figure 1 and described in corresponding text in the specification, the bank of decoders is coupled to the multi-user detector, and the decoders receive “estimates for the most probable digital bits,” which are symbol estimates, from the multi-user detector. *Id.*; *see also id.*, 28:53-57 (“The MUD algorithm ... computes estimates of the transmitted channel symbols, and passes them to a bank of single-user decoders with one decoder assigned for each user.”), 5:47-50 (“The decoder implements a decoding algorithm to generate the digital data signal.”). Brommer also teaches that in a “soft output” system, the decoder output “indicate[s] both the discrete estimate and *the probability that the estimate is correct*,” meaning that the decoder provides symbol likelihood estimates. *Id.*, 28:58-63.

120. In addition, this process in Brommer “proceeds for several iterations,” with the “data generally loop[ing] within the MUD section until a fixed number of iterations is satisfied or a certain level of accuracy is achieved.” *Id.*, 15:31-35, 28:56-

57. In my opinion, a POSITA would have understood that the “data” that loops in the MUD section would include the symbol likelihood estimates. The symbol likelihood estimates would thus be fed back to the multi-user detector in each iteration, until the process terminates based on some final condition. In my opinion, a POSITA would also have understood that at least one symbol estimate is produced for each user in each iteration; thus, across the plurality of iterations, a plurality of symbol likelihood estimates are produced for each user.

121. In the combined system, the estimates and probabilities would also be iteratively fed back to Lilleberg’s second estimation means. Lilleberg expressly teaches that the “symbol estimates” produced by the “detection means” are “supplied further to the other parts of the receiver,” which includes the “second estimation means.” Ex. 1007, 3:27-29, 3:56-64; *see also id.*, 4:1-24 (describing how the second estimation means estimates parameters using a “signal which has undergone interference elimination,” based on the symbol estimates from the previous iteration).

122. Accordingly, Brommer in view of Lilleberg and Hottinen renders obvious this element.

3. **Claim 2: “The apparatus according to claim 1, wherein said final condition is selected from at least one of the group consisting of bit error rate metric level and fixed number of iterations.**

123. Brommer discloses this claim.

124. Brommer discloses that symbol estimates are iteratively fed back to the multi-user detector for a fixed number of iterations. Specifically, in describing the system illustrated in Figure 1, Brommer explains, “[t]he data generally loops within the MUD Section until a fixed number of iterations is satisfied or a certain level of accuracy is achieved.” Ex. 1004, 15:20-35; *see also id.*, 28:56-57 (regarding Figure 8, explaining that “[t]his process proceeds for several iterations, eventually recovering the input bit streams of all transmitted signals”).

125. Accordingly, Brommer renders obvious this claim.

4. **Claim 3: “The apparatus according to claim 1, wherein said symbol estimator is a member selected from at least one member of the group consisting of Minimum Mean Squared Error (MMSE), maximum likelihood, M-algorithm, T-algorithm, and Q-algorithm, decorrelating decision-feedback detector (DDFD), improved decorrelating decision-feedback detector (IDDFD), successive interference cancellation (SIC), parallel interference cancellation (PIC) and multi-stage detector; block-iterative interference cancellation, and a deferred decorrelating decision-feedback detector.”**

126. Brommer discloses this claim.

127. As I discuss above in the context of Limitation 1[c], Brommer’s joint detector 720 and code processor 725 generate preliminary and updated symbol estimates, respectively. *See* Ex. 1004, 26:1-3 (“The joint detector 720 makes preliminary estimates of the interfering digital signal values containing [*sic*] in the

received signal.”), 26:5-8 (“The preliminary symbol estimates ... are also sent to a code processor 725 that uses properties of the data encoding to update the preliminary estimates.”). The symbol estimates are updated between the code processor and joint detector using an iterative MUD process. *Id.*, 26:9-13 (“Iteration between the code processor and the joint detector [uses] a procedure well known as iterative processing or turbo MUD.”). Brommer teaches that “any number of MUD techniques” may be used for the symbol estimation performed by the joint detector and code processor. *Id.*, 26:13-14. Brommer specifically identifies “the M or T algorithms” and “minimum means squared error (MMSE)” as techniques that may be used. Ex. 1004, 28:58-29:4; *see also id.*, claims 13-14. Brommer also identifies “successive interference cancellation” and “maximum likelihood MUD” as other known multiuser detectors. *Id.*, 26:36-49 (“[A] maximum likelihood estimator could be employed.”), 28:1-11 (referencing “maximum likelihood MUD” and “successive interference cancellation”).

128. Accordingly, Brommer renders obvious this element.

B. Ground 2: Claim 4 Is Rendered Obvious in view of Brommer, Lilleberg, Hottinen, and Learned

129. I provide a summary of this ground as follows.

130. Brommer, Lilleberg, and Hottinen render obvious claims 1-3, as discussed in Ground 1 above. Learned discloses a power-based tree pruning method

for a multi-user detection scheme. As I set forth below, in my opinion it would have been obvious to a POSITA to combine the references.

1. Motivation to Combine and Reasonable Expectation of Success

131. In my opinion, a POSITA would have been motivated to apply Learned's energy detection techniques to Brommer's MUD receiver.

132. In my opinion, Learned provides express motivations to add tree-pruning to a MUD receiver. Specifically, Learned teaches that tree-pruning improves MUD processing because a "reduced tree search, referred to as 'tree pruning' reduces the number of calculations that must be made and therefore speeds the overall tree processing." Ex. 1005, 2:49-52. Learned also teaches that using power ordering to construct the decoding tree is advantageous over prior art tree-pruning approaches, because "a reduced search is more likely to include paths (and nodes) containing the right answer," and "a low complexity suboptimal search of the tree will be less likely to chop off branches containing the correct answer, thus supplying the correct answer more often than when power ordering is not used." *Id.*, 4:67-5:7. Accordingly, in my opinion a POSITA would have understood that Learned's power-ordered tree-pruning can be used to build MUD systems with reduced complexity, increased speed, and increased accuracy compared to the prior art.

133. In my opinion, a POSITA would have also found express motivation to add tree-pruning, such as the tree-pruning technique taught by Learned, based on Brommer's teachings. In Brommer's discussion of multi-user detection techniques in the context of Figure 8, Brommer explains that "[r]educd complexity approaches based on tree-pruning help to some extent to alleviate the problems involved with optimal MUD processing." Ex. 1004, 28:12-14. However, Brommer notes that prior art tree-pruning techniques have problems with "improper pruning," which typically had to be solved by increasing the complexity of the system. *Id.*, 28:34-39. Accordingly, in my opinion a POSITA would have been motivated to apply Learned's power-ordered tree-pruning technique, which substantially reduces "improper pruning," and thus would reduce the complexity of the system.

134. In my opinion, a POSITA would have reasonably expected this combination to succeed. Brommer acknowledges that tree-pruning was a well-known technique that had long been used in the field. Ex. 1004, 28:12-40. In my opinion, a POSITA would have been familiar with tree-pruning in a MUD receiver, and would have been capable of implementing tree-pruning in Brommer's system, particularly since Brommer already describes "tree-pruning based MUD" as an implementation option. Further, in my opinion, a POSITA would understand that Learned expressly teaches how to use parameter estimation (for example, as performed by Brommer's parameter estimator or synchronizer) to perform power

ordering of user signals in order to enhance conventional tree-pruning implementations. In my opinion, a POSITA would therefore expect Learned's power-ordered tree-pruning MUD to be applicable to Brommer's system, and would be capable of implementing Learned's tree-pruning techniques in Brommer's system.

135. Finally, in my opinion, Brommer, Lilleberg, Hottinen, Learned, and the '703 patent are analogous art because all five are directed to the same field of multi-user detection. Ex. 1001, 1:24-27 ("The present invention relates to communications and more particularly to co-channel communications, and more particularly to increasing capacity by allowing interfering channels."), Ex. 1004, 10:62-65 ("it is a general object of the present invention to provide a novel and useful digital recording implementation that uses multi-user detection techniques that can solve the problems described herein"), Ex. 1005, 1:13-15 ("This invention relates to the field of communications and more particularly to an improved method and apparatus in a receiver for multi-user detection utilizing tree pruning."); Ex. 1007, Abstract ("A method for estimating a channel in a receiver of a cellular radio system ... for subjecting the received signal to elimination of multiple access interference."); Ex. 1009, 1:9-15 ("The present invention relates to a signal detection method ... in which a primary signal and at least one interfering co-channel signal are received.").

2. Claim 4: “The apparatus according to claim 1, further comprising an energy detector coupled to said joint amplitude estimator.”

136. In my opinion, Brommer, in combination with Lilleberg, Hottinen and Learned renders this claim obvious.

137. In my opinion, it would have been obvious to a POSITA to include an energy detector coupled to a joint amplitude estimator (*i.e.*, Lilleberg’s second estimation means as applied to Brommer’s system) in view of Learned. Learned discloses a multi-user detection system with a “user information assembler unit 12 which receives its information from parameter estimation unit 11.” *Id.*, 10:35-39. The MUD receives “power order information, as well as all other parameter values for each detected user, ... from user information assembler unit 12,” and uses it to “build its decoding tree by assigning the indices of active users within a symbol interval according to the power level of each received signal.” *Id.*, 11:14-22. In my opinion, a POSITA would thus understand that Learned’s parameter estimation unit includes a power detector, in order to supply power information to the user information assembler unit. It would have been obvious to a POSITA to implement Learned’s power detection using an energy detector because power corresponds to a rate at which energy is used or transmitted over time. As discussed above, in my opinion, a POSITA would have been motivated to combine the references with a reasonable expectation of success.

138. In addition, in the proposed combination, the energy detector would be included in Brommer's parameter estimator or synchronizer. That is consistent with Learned's teaching that its parameter estimation unit "determine[s] a number of unique parameters that uniquely define the characteristics of each of the plurality of received, interfering signals," including "most importantly, the received power of each of the received signals." Ex. 1005, 4:42-52. As I discussed above, in connection with Limitation 1[b] in Ground 1, in the combined system of Brommer, Lilleberg, and Hottinen, Brommer's parameter estimator and synchronizer are coupled to the Lilleberg's second estimation means, which performs joint amplitude estimation as taught by Hottinen. Accordingly, in my opinion a POSITA would understand the energy detector as taught by Learned would also be coupled to the second estimation means in the combined system.

139. Accordingly, Brommer, in combination with Lilleberg, Hottinen and Learned render this claim obvious.

C. Ground 3: Claim 5 Is Rendered Obvious in view of Brommer, Lilleberg, Hottinen, and ElGamal

140. I provide a summary of this ground as follows.

141. Brommer, Lilleberg, and Hottinen disclose and render obvious claims 1-3, as I explain above in connection with Ground 1. ElGamal similarly discloses a multi-user detection scheme, but also identifies several well-known decoding

algorithms that may be used for the decoders. As I explain below, in my opinion it would have been obvious to a POSITA to combine the references.

1. Motivation to Combine and Reasonable Expectation of Success

142. In my opinion, a POSITA would have been motivated to apply ElGamal's decoding algorithms to Brommer's receiver for processing multi-user signal streams.

143. Although ElGamal relates to a wireless communication system, and not a digital media storage system like Brommer, in my opinion Brommer provides a motivation to look to multi-user detection techniques used in other applications, including wireless communication systems, and a POSITA would know to look to such systems to improve Brommer's multi-user detector. Specifically, Brommer states that "[t]here are various modes of MUD processing known in the art, however the implementation in a disk drive scenario has heretofore not been accomplished." Ex. 1004, 15:33-35. Accordingly, in my opinion, a POSITA would have been motivated to look to other "modes" of MUD processing to improve Brommer's implementation, including MUD processing in wireless communication systems.

144. As I discussed above in the context of Limitation 1[d] in Ground 1, Brommer discloses a bank of decoders. But Brommer does not require a specific decoding algorithm to be used. Brommer does explain that its multi-user detector

can employ an algorithm “based upon MAP, Log-MAP, or Max-Log MAP detectors,” but does not clearly link those algorithms to the decoders in the system. Ex. 1004, 13:31-33; *see also id.*, 5:47-48 (“The decoder implements a decoding algorithm to generate the digital data signal.”). In any event, in my opinion, a POSITA would have understood that any known decoding algorithm may be used in Brommer’s system.

145. ElGamal, like Brommer, also discloses “multi-user detection algorithms.” Ex. 1008, 8:66-9:2. Like Brommer, ElGamal’s multi-user detection algorithm includes a parameter estimator, a multi-user detector, and “channel decoders ... associated with the component channel codes.” *Id.*, 9:8-14. Unlike Brommer, however, ElGamal describes several decoding algorithms that may be used in its decoders, including “the maximum a-posteriori (MAP) approach,” “the (log-MAP) approach,” and “the soft output Viterbi algorithm (SOVA),” and explains that the choice “depends on the available processing power at the receiver.” *Id.*, 9:26-34. In my opinion, a POSITA would have been familiar with these well-known decoding algorithms, and would have found it obvious to use any of them in Brommer’s decoders, because they would have been suitable to solve the same problem in Brommer’s system, *i.e.*, decoding the received data stream.

146. In my opinion, a POSITA would have reasonably expected this combination to succeed. ElGamal’s decoding algorithms are conventional decoding

algorithms that a POSITA would have been familiar with and would have known how to implement in Brommer's system. In addition, Brommer expressly discloses that its system can employ an algorithm "based upon MAP, Log-MAP, or Max-Log MAP detectors." Ex. 1004, 13:31-33. Accordingly, in my opinion a POSITA would have understood that at least MAP and log-MAP decoders would be compatible with Brommer's system. In my opinion, a POSITA would have further understood that these references disclose interrelated teachings based on routine technologies and would have been amenable to various well-understood and predictable combinations.

147. Finally, in my opinion Brommer, Lilleberg, Hottinen, ElGamal, and the '703 patent are analogous art because all five are directed to the same field of multi-user detection, that is, processing a data stream from multiple users using joint signal detection techniques. Ex. 1001, 1:24-27 ("The present invention relates to communications and more particularly to co-channel communications, and more particularly to increasing capacity by allowing interfering channels."), Ex. 1004, 10:62-65 ("it is a general object of the present invention to provide a novel and useful digital recording implementation that uses multi-user detection techniques that can solve the problems described herein"), Ex. 1007, Abstract ("A method for estimating a channel in a receiver of a cellular radio system ... for subjecting the received signal to elimination of multiple access interference."); Ex. 1009, 1:9-15 ("The present

invention relates to a signal detection method ... in which a primary signal and at least one interfering co-channel signal are received.”); Ex. 1008, 1:24-27 (“The invention also relates to a method and apparatus for ... multi-user detection and decoding in a multiple antenna wireless communication system.”).

2. Claim 5: “The apparatus according to claim 1, wherein said bank of decoders are decoders selected from at least one decoder of the group consisting of Soft-output Viterbi, Maximum A Posteriori, and Bahl-Cocke-Jelinek-Raviv.”

148. In my opinion, Brommer and ElGamal render obvious this claim.

149. Brommer discloses that in one implementation, its multi-user detector can employ an algorithm “based upon MAP, Log-MAP, or Max-Log MAP detectors.” Ex. 1004, 13:31-33. Brommer does not expressly state that its decoder implements this algorithm. With respect to its decoders, Brommer only generally states that “[t]he decoder implements a decoding algorithm to generate the digital data signal.” *Id.*, 5:47-48. However, in my opinion it would have been obvious to a POSITA to use the MAP or soft-output Viterbi algorithms for Brommer’s decoders in light of ElGamal.

150. ElGamal discloses a bank of “SISO channel decoders 48 a through 48 n.” Ex 1008, 9:26-27; *see also id.*, Figs. 4-5. ElGamal teaches the decoders “can employ any of the following algorithms,” including “maximum a-posteriori (MAP)” or “the soft output Viterbi algorithm.” *Id.*, 9:27-32. As I discussed above, a POSITA

would have been motivated to combine the references with a reasonable expectation of success.

151. Accordingly, Brommer in view of Elgamal render this claim obvious.

D. Ground 4: Claims 1-3 and 5 are Rendered Obvious by Frank in view of Zha

152. I provide a summary of this ground as follows.

153. Frank discloses a receiver that includes a multi-user detection algorithm comprising linear MMSE equalization with successive or parallel interference cancellation. Zha discloses an improvement to successive interference cancellation in multi-user detection algorithms by averaging amplitude estimates over multiple samples (*i.e.*, joint amplitude estimation). As I explain below, in my opinion, it would have been obvious to a POSITA to apply Zha's teachings to Frank.

1. Motivation to Combine and Reasonable Expectation of Success

154. In my opinion, a POSITA would have been motivated to apply Zha's amplitude averaging methods and soft bit decision rule to Frank's CDMA receiver with MMSE equalization and interference cancellation.

155. Frank discloses a CDMA receiver for multi-user detection that employs parallel or successive interference cancellation. Ex. 1006, [0009]. Zha teaches specific improvements to CDMA systems that perform successive interference cancellation (SIC). *See* Ex. 1010. In particular, Zha teaches that "amplitude

estimation by averaging over M bits can result in significant performance improvement over no averaging for the SIC receiver.” Ex. 1010, 743. In addition, Zha proposes a data bit decision rule “that combine[s] the advantages” of soft-decision rules and hard-decision rules to “achieve a performance close to that of the single user bound.” *Id.* In my opinion, these teachings would motivate a POSITA to apply Zha’s improvements using amplitude averaging and data bit decision rules to Frank’s system using successive interference cancellation in order to achieve similar, predictable improvements in Frank’s CDMA receiver. A POSITA would have also understood that Zha’s improvements are complementary to those proposed by Frank. Frank improves on conventional interference cancellation by adding linear MMSE equalization. Ex. 1006, [0007]. Zha’s improvements using amplitude averaging and improved bit decision rules could be added on top of on top of Frank’s linear MMSE equalization to improve performance even more.

156. In my opinion, a POSITA would have reasonably expected this combination to succeed. Successive interference cancellation was well known in the field prior to the ’703 patent, and would have been familiar to a POSITA. Zha discloses specific improvements to these well-known techniques, which a POSITA would have been capable of applying to Frank’s receiver. Implementing Zha’s improvements in Frank’s system would have been well within the capabilities of a POSITA.

157. Finally, in my opinion, Frank, Zha, and the '703 patent are analogous art because all three are directed to the same field of multi-user detection, that is, processing a data stream from multiple users using joint signal detection techniques. Ex. 1006, [0001] (“The present invention relates, in general, to receivers for code division multiple access (CDMA) communication systems”), [0005] (CDMA ... has multiple users plus noise in the channel.”); Ex. 1010, 743 (“Successive interference cancellation (SIC) is a low-complexity multiuser detection method for DS/CDMA systems. ... We propose a new soft-decision rule to be used with amplitude averaging.”); Ex. 1001, 1:24-27 (“The present invention relates to communications and more particularly to co-channel communications, and more particularly to increasing capacity by allowing interfering channels.”).

2. Claim 1

(a) 1[pre]: “An apparatus for processing a digital data stream from multiple users, comprising:”

158. In my opinion, Frank discloses this element to the extent the preamble is limiting.

159. Frank discloses “receivers for code division multiple access (CDMA) communication systems.” Ex. 1006, [0001]. In my opinion, a POSITA would have known that CDMA communication systems include data streams from multiple users. Frank’s receivers also receive and process a digital data stream from multiple

users, such as a signal in a CDMA communication system. Ex. 1006, [0018] (“A received signal, such as a CDMA signal received by a mobile station.”), claim 1 (a “multiple access communication system having a plurality of code channels in use.”)

160. Accordingly, Frank discloses this element.

(b) 1[a]: “an initial amplitude estimation unit processing said data stream and producing initial amplitude estimates on a first iteration”

161. In my opinion, Frank discloses this element.

162. Frank discloses an “amplitude estimator.” Ex. 1006, [0019], Fig. 1. The amplitude estimator receives as input a filtered and despread received signal, which is part of the data stream, and determines “an amplitude estimate for all corresponding channels of the plurality of channels.” *Id.*, [0008]; *see also id.*, [0019] (equating each “channel code” with a “user[]” or “logical channel[]”), [0050] (“Amplitude estimates are ... made for each orthogonal code channel.”). In my opinion, a POSITA would have understood that each channel code in a CDMA system corresponds to a user.

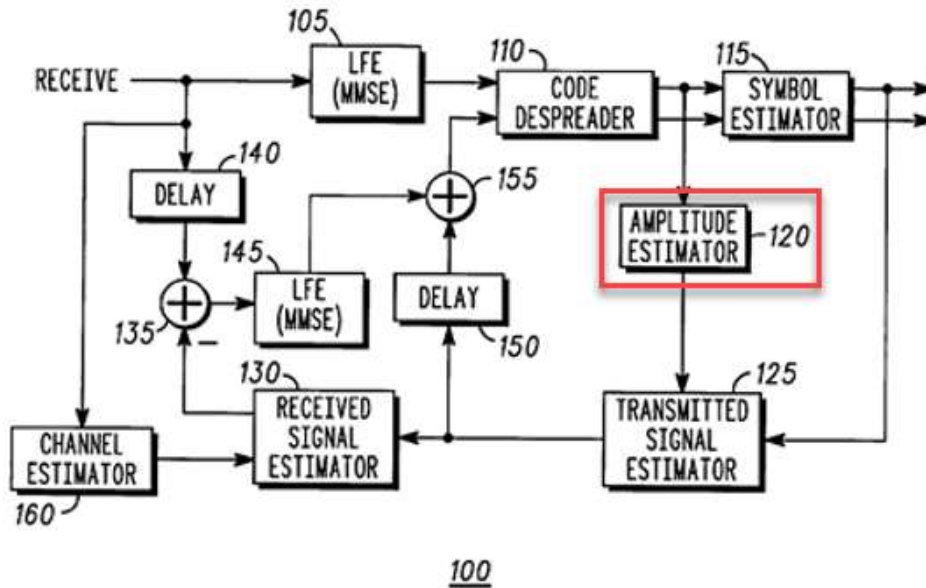
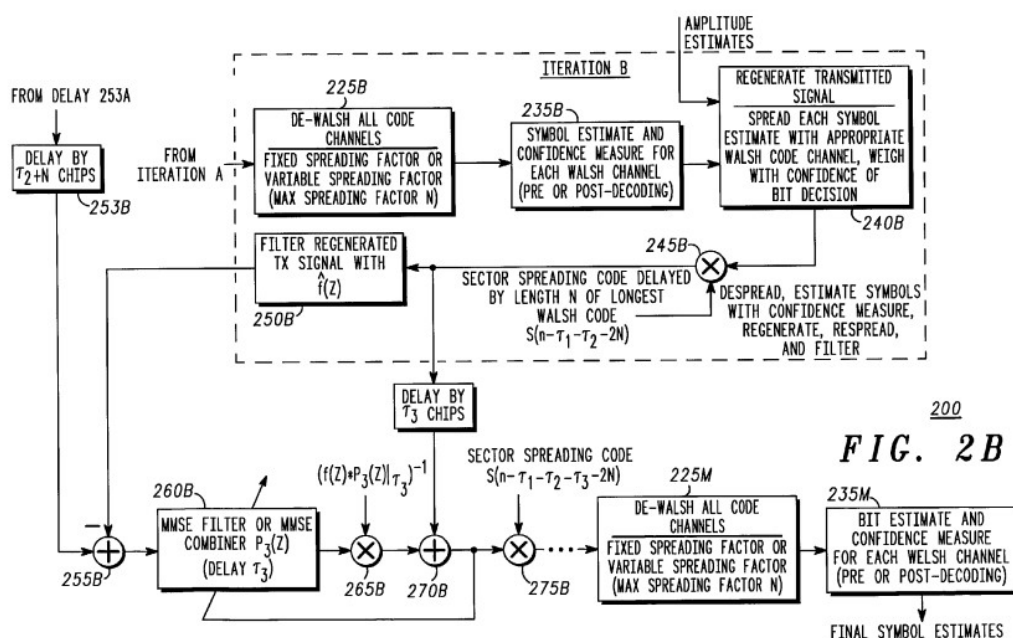
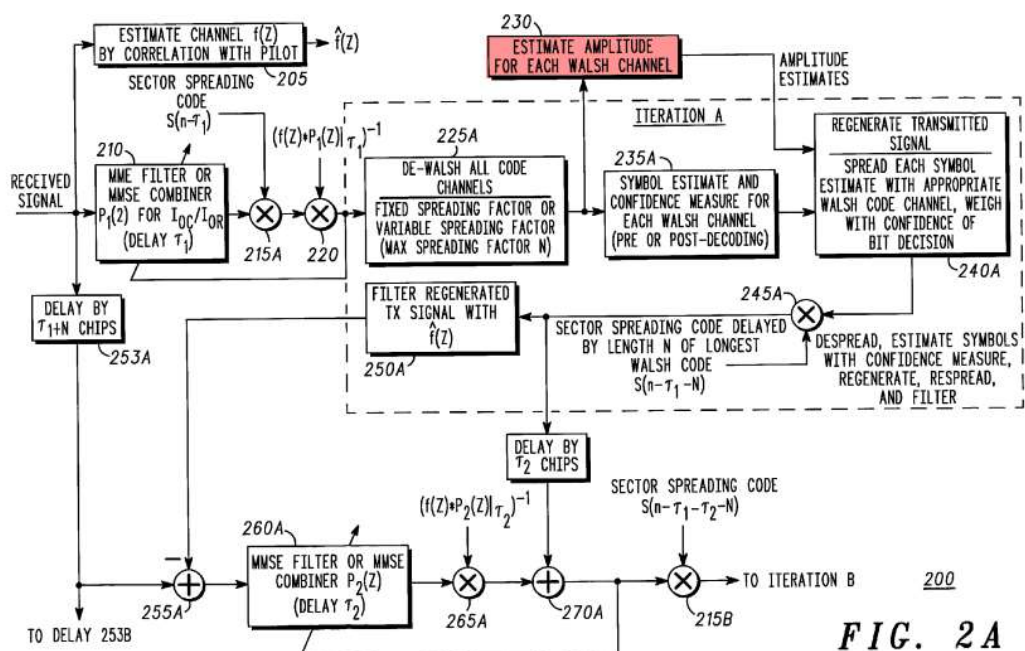


FIG. 1

163. In addition, a POSITA would have understood that Frank's amplitude estimator determines an initial amplitude because it estimates the amplitude during the first iteration only. For example, in Figures 2A and 2B, Frank shows that an "estimate amplitude for each Walsh channel" function 230 is performed as part of Iteration A (the first iteration). In iteration 2B, however, there is no separate "estimate amplitude for each Walsh channel" function, yet "amplitude estimates" are still received. Further, Figure 2A and 2B expressly labels functional blocks as "A" and "B" if they are performed in multiple iterations (e.g., blocks 235A and 235B, corresponding to symbol estimation in the first and second iterations). A POSITA would have thus understood that in Frank's system, the amplitude estimates are computed initially in the first iteration.



164. Accordingly, Frank discloses this element.

(c) 1[b]: “a joint amplitude estimator coupled to said data stream and said initial amplitude estimator, wherein said joint amplitude estimator produces updated amplitude estimates”

165. In my opinion, Frank in view of Zha renders obvious this element.

166. Although Frank discloses an amplitude estimator, Frank does not expressly disclose a joint amplitude estimator that produces updated amplitude estimates. In my opinion, however, it would have been obvious to a POSITA to provide a joint amplitude estimator that produces updated amplitude estimates in Frank’s system in view of Zha.

167. Zha discloses a “SIC [successive interference cancellation] receiver with amplitude averaging” that “has multiple interference cancellation stages, starting from stage $\nu = 1$.” Ex. 1010, 744. “During the $(\nu+1)$ st stage”—meaning, in each iteration after $\nu = 1$, or in each iteration other than the first iteration—“the averaged amplitude estimate” is determined for each user “by averaging the instantaneous estimate of [the user’s] amplitudes over a block of M bits after despreading.” *Id.* These averaged amplitude estimates are the same as the joint amplitude estimates described in the ’703 patent. For example, the ’703 patent explains that its joint amplitude estimator “combines individual [amplitude] estimates, Δa_m ” which are “the individual estimates ... for each [observation] interval 1- M .” Ex. 1001, 19:64-20:15. Zha’s averaged amplitude estimates perform

the same calculation: they process “(M + 1) observation intervals” by “averaging” (which is one manner of combining) “the instantaneous estimate of” a given user’s individual “amplitudes over a block of M bits.” Ex. 1010, 744. This process in Zha is repeated in every stage of Zha after the first stage, and thus computes new, updated amplitude estimates for each stage based on the interference cancellation performed in the previous stage. Ex. 1010, 744.

168. In the combined system of Frank and Zha, the amplitude averaging element would be coupled to Frank’s data stream and (initial) amplitude estimator. It would be coupled to the data stream because Zha’s averaged amplitude estimation

$\bar{A}_k^{v+1}$, is calculated based on each user’s estimated received signal as an input, $\tilde{\mathbf{r}}_k^{v+1}$; and each user’s estimated received signal is determined based on the original, combined received signal $\mathbf{r}$. Ex. 1010, 744. This is illustrated in the equations below from Zha:

$$\bar{A}_k^{v+1} = \frac{1}{M} \sum_{i=1}^M \text{abs} \left(\text{Re} \left(e^{-j\theta_k} (\mathbf{d}_k(i))^H \tilde{\mathbf{r}}_k^{v+1} \right) \right)$$

$$\begin{aligned}\tilde{\mathbf{r}}_k^{v+1} = & \mathbf{r} - \sum_{l=1}^{k-1} \sum_{i=1}^M e^{j\theta_l} \bar{A}_l^{v+1} \hat{b}_l^{v+1}(i) \mathbf{d}_l(i) \\ & - \sum_{l=k+1}^K \sum_{i=1}^M e^{j\theta_l} \bar{A}_l^v \hat{b}_l^v(i) \mathbf{d}_l(i)\end{aligned}$$

169. The joint amplitude estimator of the '703 patent similarly uses an estimated received signal to compute amplitude estimates. Ex. 1001, 19:47-67.

170. The amplitude averaging element in the combined system would also be coupled to Frank's (initial) amplitude estimator, because each iteration after the first (*i.e.*, the “(v+1)st stage”) relies on the previous iteration's amplitude estimates to produce updated amplitude estimates. Ex. 1010, 744. Specifically, in the equations reproduced above, $\tilde{\mathbf{r}}_k^{v+1}$ is computed in part by subtracting out the previous iteration's amplitude estimates, $\bar{A}_l^v$, for certain users. Thus, in at least the second iteration, the amplitude averaging element in the combined system must receive and use the amplitude estimates from the initial amplitude estimator.

171. A POSITA would have been motivated to apply Zha's teachings regarding joint amplitude estimation and producing updated amplitude estimates to Frank's system, and would have reasonably expected to be successful in doing so, for the reasons I discuss in Section VII.D.1 above.

172. Accordingly, Frank in view of Zha renders obvious this element.

- (d) **1[c]: “a symbol estimator coupled to said data stream, said initial amplitude estimator, and said joint amplitude estimator, wherein said symbol estimator produces a plurality of symbols estimates for each user; and”:**

173. In my opinion, Frank renders obvious this element.

174. Frank discloses “symbol estimator 115, which produces an output stream consisting of symbol estimates or (soft) symbol decisions.” Ex. 1006, [0019], [0008]. In addition, the symbol estimates are determined for “each code channel,” which a POSITA would have understood corresponds to each user. *Id.*, [0032]; *see also id.*, Fig. 2 (element 235A).

175. As shown in Figure 1, and as in my opinion as a POSITA would understand from Fig. 1, the symbol estimator to the received signal (after filtering and despreading), which is the data stream. It is also coupled to the amplitude estimator 120. *Id.*, Fig. 1. Frank also discloses that the symbol estimator may produce reliability estimates for each symbol estimate using “the amplitude estimate for the given code channel.” *Id.*, [0032]-[0033]. In order to do so, the symbol estimator must be coupled to the (initial) amplitude estimator so that it receives amplitude estimates for generating symbol reliability estimates. For the same reason, in the combined system, where Zha’s averaged amplitude estimation is used to compute updated amplitude estimates in each iteration, the averaged amplitude

estimates would be coupled to the symbol estimator for generating reliability estimates.

176. Accordingly, Frank renders obvious this element.

- (e) **1[d]: “a bank of decoders coupled to said symbol estimator, producing a plurality of symbol likelihood estimates for each user, wherein said symbol likelihood estimates are iteratively fed back to said symbol estimator and said joint amplitude estimator until a final condition is obtained.”:**

177. In my opinion, Frank in view of Zha renders obvious this element. Specifically, it would have been obvious to a POSITA to provide a bank of decoders to produce symbol likelihood estimates for each user in Frank’s system in view of Zha.

178. Zha discloses that after “soft data bit estimates” are determined for each user, a “data bit decision” for each user k is made by a “decision rule f_{dec} .” Ex. 1010, 744. In my opinion, a POSITA would have understood that the “decision rule” would be implemented using a decoder, as decoders typically make bit decisions. A POSITA would thus also understand that Zha’s data bit decisions are performed by a bank of decoders, with one decoder for each user’s data bit decision. As shown in

Zha, the bit decision for user k , $\hat{b}_k^{v+1}(i)$ is determined by applying the decision rule to the soft data bit estimate $\tilde{b}_k^{v+1}(i)$. Thus, Zha’s decoders must be coupled

to Frank's symbol estimator in order to receive symbol estimates (soft data bit estimates) to decode.

179. Zha also discloses that the "decision rule" is a "soft bit decision rule." Ex. 1010, 744. In my opinion, a POSITA would have understood that a soft bit decision rule determines a symbol value and an associated produces symbol likelihood estimates. In Zha, the symbol likelihood estimates are used in the subsequent iteration in performing interference cancellation for each user. Ex. 1010, 744. This necessarily means that the symbol likelihood estimates are iteratively fed back to the amplitude estimator and symbol estimator, which operate on the data stream after interference cancellation is performed.

180. Zha also teaches that the process "terminate[s] after a desired number of cancellation stages," which is a final condition. Ex. 1010, 744. That is, the specified number of stages is the "final condition" that causes the process to terminate.

181. Accordingly, Frank in view of Zha renders obvious this element.

3. Claim 2: "The apparatus according to claim 1, wherein said final condition is selected from at least one of the group consisting of bit error rate metric level and fixed number of iterations."

182. In my opinion, Frank and Zha render obvious this claim.

183. As discussed above for Limitation 1[d], in the combined system, Zha's decision rules iteratively feed back data bit decisions and "terminate[]" after a desired number of cancellation stages." Ex. 1010, 744. The desired number of cancellation stages correspond to a fixed number of iterations. Frank similarly teaches performing interference cancellation until "an iteration limit has been exceeded." Ex. 1006, [0042].

184. Accordingly, Frank in view of Zha renders obvious this claim.

4. **Claim 3: "The apparatus according to claim 1, wherein said symbol estimator is a member selected from at least one member of the group consisting of Minimum Mean Squared Error (MMSE), maximum likelihood, M-algorithm, T-algorithm, and Q-algorithm, decorrelating decision-feedback detector (DDFD), improved decorrelating decision-feedback detector (IDDFD), successive interference cancellation (SIC), parallel interference cancellation (PIC) and multi-stage detector; block-iterative interference cancellation, and a deferred decorrelating decision-feedback detector."**

185. In my opinion, Frank discloses this claim.

186. Frank expressly discloses that its symbol estimator may perform "successive interference cancellation" or "parallel interference cancellation." Ex. 1006, [0001] ("The present invention relates ... to receivers having linear, minimum mean square error equalization with successive or parallel interference cancellation."), [0025] (describing embodiment using parallel interference cancellation), [0040] (describing receivers implemented "in a successive

interference cancellation mode”). In the combined system, a POSITA would use successive interference cancellation for symbol estimation because Zha teaches that its improvements are particularly beneficial for successive interference cancellation.

187. Accordingly, Frank discloses this claim.

5. Claim 5: “The apparatus according to claim 1, wherein said bank of decoders are decoders selected from at least one decoder of the group consisting of Soft-output Viterbi, Maximum A Posteriori, and Bahl-Cocke-Jelinek-Raviv.”

188. In my opinion Frank discloses this claim.

189. Frank teaches that “[d]ecoders for all types of codes (block, convolutional, trellis, and turbo) can be designed to yield reliability estimates for each of the channel symbols.” Ex. 1006, [0033]. Frank specifically identifies the “soft-output Viterbi algorithm” as “one such algorithm for trellis codes.” *Id.*

190. Accordingly, Frank discloses this claim.

E. Ground 5: Claim 4 Is Rendered Obvious by Frank in view of Zha and Learned.

191. I provide a summary of this ground as follows.

192. Frank and Zha disclose and render obvious claims 1-3 and 5, as I explain above in connection with Ground 4. Learned further discloses a power-based tree pruning method for a multi-user detection scheme. As set forth below, it would have been obvious to a POSITA to combine the references.

1. Motivation to Combine and Reasonable Expectation of Success

193. In my opinion, a POSITA would have been motivated to apply Learned's energy detection techniques to Frank's MUD receiver.

194. As I discussed in Ground 2, Learned provides express motivations to add tree-pruning to a MUD receiver. *See* Section VIII.B.1; Ex. 1005, 2:49-52. Learned also teaches that using power ordering to construct a decoding tree is advantageous over the prior art. *Id.*, 4:67-5:7. Thus, in my opinion a POSITA would have understood that Learned's power ordered tree-pruning implementation enables MUD systems with reduced complexity, increased speed, and increased accuracy compared to the prior art.

195. In my opinion, Frank also provides express motivation to add tree-pruning, such as the tree-pruning technique taught by Learned, to its system. Frank recognizes that certain receivers have been used in the prior art "for their low complexity," but notes that those receivers "are not optimal in terms of performance." Ex. 1006, [0004]. Frank proposes using MMSE equalization to with parallel interference cancellation to provide "significantly improved performance." *Id.*, [0007]. However, Frank acknowledges that its invention is "computationally intensive." *Id.*, [0024]. Although Frank proposes some simplifications that "reduce complexity," it acknowledges that "performance will be degraded." *Id.*, [0023].

Accordingly, in my opinion a POSITA would have been motivated to apply Learned's power-ordered tree-pruning technique, which reduces complexity while also minimizing degradation of performance.

196. In my opinion, a POSITA would have reasonably expected this combination to succeed. As I explained in Section VII.B.1, tree-pruning was a well-known technique that had long been used in the field, and in my opinion a POSITA would have been familiar with its implementation in a MUD receiver and capable of implementing it in Frank's system. Further, in my opinion a POSITA would understand that Learned expressly teaches how to use a parameter estimator (*e.g.*, Frank's amplitude estimator) to determine signal power and perform power ordering of user signals in order to enhance conventional tree-pruning implementations. In my opinion, a POSITA would therefore expect Learned's power-ordered tree-pruning MUD to be applicable to Frank's system, and would be capable of implementing the same within Frank.

197. Finally, in my opinion Frank, Zha, Learned, and the '703 patent are analogous art because all four are directed to the same field of multi-user detection, and all consider trade-offs between performance and complexity. Ex. 1001, 1:24-27 ("The present invention relates to communications and more particularly to co-channel communications, and more particularly to increasing capacity by allowing interfering channels."), Ex. 1005, 1:13-15 ("This invention relates to the field of

communications and more particularly to an improved method and apparatus in a receiver for multi-user detection utilizing tree pruning.”); Ex. 1006, [0001] (“The present invention relates, in general, to receivers for code division multiple access (CDMA) communication systems”), [0005] (CDMA ... has multiple users plus noise in the channel.”); Ex. 1010, 743 (“Successive interference cancellation (SIC) is a low-complexity multiuser detection method for DS/CDMA systems. ... We propose a new soft-decision rule to be used with amplitude averaging.”).

2. Claim 4: “The apparatus according to claim 1, further comprising an energy detector coupled to said joint amplitude estimator.”

198. In my opinion, Frank, Zha, and Learned render obvious this claim.

199. In my opinion, it would have been obvious to a POSITA to include an energy detector coupled to the amplitude averaging element in the combined Frank/Zha system in view of Learned. As I discuss above in Ground 2, Learned discloses a multi-user detection system with a “user information assembler unit 12 which receives its information from parameter estimation unit 11.” *Id.*, 10:35-39. The MUD receives “power order information, as well as all other parameter values for each detected user, ... from user information assembler unit 12,” and uses it to “build its decoding tree by assigning the indices of active users within a symbol interval according to the power level of each received signal.” *Id.*, 11:14-22. In my opinion, a POSITA would thus understand that Learned’s parameter estimation unit

includes a power detector, in order to supply power information to the user information assembler unit. In my opinion, it would further be obvious to a POSITA to implement Learned's power detection using an energy detector because power corresponds to a rate at which energy is used or transmitted over time. *Id.*

200. Accordingly, Frank, Zha, and Learned render obvious this claim.

VIII. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

201. I am not aware of any secondary considerations, or so-called "objective indicia of non-obviousness" for the challenged claims.

202. Secondary considerations could include things like commercial success of a product due to the merits of the claimed invention; a long felt need for the solution provided by the claimed invention; unsuccessful attempts by others to find the solution provided by the claimed invention; copying of the claimed invention by others; unexpected and superior results from the claimed invention; acceptance by others of the claimed invention as shown by praise from others in the field or from the licensing of the claimed invention; teaching away from the conventional wisdom in the art at the time of the invention; independent invention of the claimed invention by others before or at about the same time as the named inventor thought of it; and other evidence tending to show obviousness.

203. Patent Owner has not identified any such secondary considerations, and I am not independently aware of any. For example, Patent Owner has no commercial

products embodying the '703 patent that I am aware of. Additionally, as discussed throughout, the claimed features reflect predictable results of combining known elements according to their known functions, and thus, there are no unexpected and superior results from the claimed invention. Also, there are no licenses of the '703 patent of which I am aware.

204. Further, even if Patent Owner were to assert that secondary considerations exist, given the strong reasons that the challenged claims are obvious in light, including the motivations to combine the references set forth above, I do not believe any such secondary considerations would rise to the level of overcoming the invalidity opinions I have expressed.

205. I understand that Patent Owner may address the issue of secondary considerations more fully in the future. I reserve the right to respond to any specific bases for such secondary considerations that Patent Owner may identify.

IX. CONCLUSION

206. For the reasons set forth above, I believe claims 1-5 of the '703 patent are unpatentable in view of the prior art. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in this case and that cross-examination will take place within the United States. If cross-examination is required of me, I

will appear for cross-examination within the United States during the time allotted for cross-examination.

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

Dated: September 30, 2024

By: 

Paul S. Min, Ph.D.