

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

INTEL CORPORATION,
LENOVO (UNITED STATES) INC.,
MOTOROLA MOBILITY LLC
Petitioners,

v.

COLLISION COMMUNICATIONS, INC.,
Patent Owner.

Case No. IPR2025-00303

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

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 7,463,703**

TABLE OF CONTENTS

	Page
I. INTRODUCTION.....	1
II. STANDING.....	7
III. GROUNDS	7
IV. POSITA.....	8
V. TECHNICAL BACKGROUND.....	8
VI. OVERVIEW OF THE '703 PATENT.....	12
A. Disclosure.....	12
B. Prosecution History	16
VII. CLAIM CONSTRUCTION.....	16
VIII. CLAIMS 1-5 ARE UNPATENTABLE OVER THE PRIOR ART.....	16
A. Ground 1: Claims 1-3 are Rendered Obvious by Brommer in view of Lilleberg and Hottinen	16
1. Brommer (U.S. Patent No. 6,826,140) (Ex. 1004)	17
2. Lilleberg (U.S. Patent No. 5,905,946) (Ex. 1007).....	19
3. Hottinen (U.S. Patent No. 5,995,499) (Ex. 1009)	20
4. Motivation to Combine.....	21
5. Claim 1	25
(a) 1[pre]: “An apparatus for processing a digital data stream from multiple users, comprising:”	25
(b) 1[a]: “an initial amplitude estimation unit processing said data stream and producing initial amplitude estimates on a first iteration”.....	26
(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”	29
(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”	31
(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.”	33
6. 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.”	35
7. 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, decorrlating decision-feedback detector (DDFD), improved decorrelating decisionfeedback 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.”	36
B. Ground 2: Claim 4 Is Rendered Obvious in view of Brommer, Lilleberg, Hottinen, and Learned	37
1. Learned (U.S. Patent No. 7,190,743) (Ex. 1005)	37
2. Motivation to Combine	39
3. Claim 4: “The apparatus according to claim 1, further comprising an energy detector coupled to said joint amplitude estimator.”	42
C. Ground 3: Claim 5 Is Rendered Obvious in view of Brommer, Lilleberg, Hottinen, and ElGamal	43
1. ElGamal (U.S. Patent No. 6,898,248) (Ex. 1008)	43
2. Motivation to Combine	45
3. 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.”	48
D. Ground 4: Claims 1-3 and 5 are Rendered Obvious by Frank in view of Zha	48
1. Frank (U.S. Patent Pub No. 2003/0035469) (Ex. 1006)	49
2. Zha (“Soft-Decision Successive Interference Cancellation CDMA Receiver with Amplitude Averaging and Robust to Timing Errors”) (Ex. 1010)	50
3. Motivation to Combine	52
4. Claim 1	54

(a) 1[pre]: “An apparatus for processing a digital data stream from multiple users, comprising:”	54
(b) 1[a]: “an initial amplitude estimation unit processing said data stream and producing initial amplitude estimates on a first iteration”	54
(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”	56
(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”	58
(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.”	59
5. 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.”	61
6. 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, decorrlating decision-feedback detector (DDFD), improved decorrelating decisionfeedback 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.”	61
7. 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.”	62
E. Ground 5: Claim 4 Is Rendered Obvious by Frank in view of Zha and Learned.	62
1. Motivation to Combine	62
2. Claim 4: “The apparatus according to claim 1, further comprising an energy detector coupled to said joint amplitude estimator.”	65

IX.	THE BOARD SHOULD NOT EXERCISE ITS DISCRETION TO DENY INSTITUTION.....	65
A.	<i>Fintiv</i>	65
B.	§ 325(d)	69
X.	MANDATORY NOTICES AND FEES	70
A.	Real Party-In-Interest	70
B.	Related Matters	70
C.	Counsel and Service Information.....	70
D.	Payment of Fees	71
XI.	CONCLUSION.....	71

EXHIBIT LIST

Ex.	Description
1001	U.S. Patent No. 7,463,703 (“’703 Patent”)
1002	Prosecution History for 7,463,703
1003	Declaration of Dr. Paul Min
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
1015	Federal Court Management Statistics (September 2024)
1016	Memorandum, Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court

	Litigation (USPTO June 21, 2022) (“Guidance Memo”)
1017	Standing Order Regarding Readiness for Scheduling Conference (Judge Rodney Gilstrap, E.D. Tex., December 20, 2011), <i>available at</i> www.txed.uscourts.gov/sites/default/files/judgeFiles/12-20-11%20Standing%20Order%20%20re%20Readiness%20for%20Scheduling%20Conference.pdf
1018	Docket Control Order, Dkt. No. 44, <i>Collision Communications, Inc. v. Lenovo Group Ltd</i> , 2-23-cv-00594 (E.D. Tex.)
1019	Additional Declaration of Dr. Paul Min

LIST OF CHALLENGED CLAIMS

Claim	Limitation
1pre	An apparatus for processing a digital data stream from multiple users, comprising:
1a	an initial amplitude estimation unit processing said data stream and producing initial amplitude estimates on a first iteration;
1b	a joint amplitude estimator coupled to said data stream and said initial amplitude estimator, wherein said joint amplitude estimator produces updated amplitude estimates;
1c	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
1d	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.
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.
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.

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

I. INTRODUCTION

Petitioners Intel Corporation (“Intel”), Lenovo (United States) Inc., and Motorola Mobility LLC (collectively “Petitioners”) request *Inter Partes* Review (“IPR”) of claims 1-5 of the ’703 patent. Petitioners also file a contingent motion to join the IPR in *Samsung Electronics America, Inc., et al. v. Collision Communications, Inc.*, Case No. IPR2024-01500 (“the Samsung IPR”), in which Samsung is challenging the same claims on the same grounds.¹ Petitioners submit this petition to preserve their motion for joinder or to allow for timely consideration of the prior art presented herein if the Samsung Petition is denied for reasons other than the likelihood of prevailing at trial.

The ’703 patent is directed to purported improvements to the well-known technique of multi-user detection (“MUD”), which allows differentiation of data streams directed to different users where multiple devices transmit signals simultaneously over a common communication channel, each carrying its own information. These devices, which are all using the same channel, interfere with one

¹ Petitioners have retained Paul Min, Ph.D. in this proceeding. Ex. 1019. Dr. Min has adopted his prior opinions set forth in Ex. 1003 (submitted in IPR2024-01500) and, for expediency, this Petition cites to Dr. Min’s previously submitted declaration, also presented herein as Ex. 1003.

another, and techniques are required to demodulate and otherwise ascertain which signal is directed to which user. This technology, MUD, was not invented by the '703 patent. Indeed, the '703 patent acknowledges that prior art describes many techniques for doing so. *See* Ex. 1001 at 6:19-25 (“There are various multiuser detectors in the art.”).

Wireless communication technologies allow multiple users to send data over the same transmission channels. Because data may be transmitted to multiple receivers at the same or overlapping times and frequencies, signals can be received as “interfering” signals—*i.e.*, a signal that suffers from interference from multiple users trying to use the same communications resource. Wireless communication technologies, such as cellular communication technologies, incorporate different methodologies of dividing transmissions into multiple parts, each part dedicated to transmitting information for a different user. For example, Code-Division Multiple-Access (“CDMA”) assigns different code waveforms to different users, and each “code” can be used to extract a particular user’s signal from the combined channel. However, these systems are not perfect, and some amount of interference between the multiple transmitted signals will typically still be detected. As the number of concurrent users on the channel increases, the magnitude of the interference will also grow.

MUD techniques have been used since the 1980s to remove interference in a

received signal. By the 1990s, researchers developed a wide variety of MUD techniques, including highly efficient techniques capable of achieving superior performance without the need for highly complex and resource intensive processing. Some of these techniques, such as a class of MUDs referred to as “subtractive interference cancellation,” work by separately estimating interference contributed by each interfering user’s signal, and subtracting out that interference from the received signal to determine each individual user’s signal. Specifically, subtractive interference cancellation iteratively determines received symbols for each user by continuously estimating the amplitudes and symbols received for each user, and jointly using those estimates to subtract interference and generate improved estimates in each subsequent iteration.

The ’703 patent is directed to the basic concept of MUD techniques that iteratively compute amplitude and symbol estimates, and update those estimates in each iteration until a final decision is reached—*i.e.*, basic, well-known iterative MUD.

The ’703 patent’s purported improvement over the prior art is simple and not inventive: it uses joint estimation of signal amplitudes and symbols to reduce interference between users, including for large numbers of concurrent users, without the need for prior knowledge about the channel, and in a manner that allows for practical, real-time processing. *See* Ex. 1001, 6:40-44 (discussing “optimal MUD”

technique that is “computationally complex and [] is not possible to accomplish in a real-time environment”), 5:50-54 (describing “decision feedback” techniques that “are incapable of working in supersaturated environments”), 7:19-45 (criticizing linear MUD techniques that “require[] knowledge of all parameters to perform processing”). But the ’703 patent’s purported solution, using a MUD with iterative joint amplitude estimation and symbol estimation, was well known at the time of the purported invention of the ’703 patent, including in the prior art presented in this petition.

This petition presents two primary references: Brommer (Ex. 1004) and Frank (Ex. 1006), both of which teach the MUD techniques claimed in the ’703 patent.

Brommer is a 2002 BAE patent (*i.e.*, the same original assignee as the ’703 patent) directed to “a processing scheme for digital storage media using multi-user detection to ... remove interference from neighboring tracks.” Ex. 1004, Abstract.

In Brommer’s implementation, multi-user detection is used to separate and remove interference from multiple tracks on a storage device, where each track functions as a user for the purposes of the detection. As illustrated in Figure 1, the data stream is processed by a “parameter estimator” for “identifying a track transfer function for the plurality of tracks,” which includes “amplitude ... of each of the plurality of data tracks.” *Id.*, 12:57-59, 13:5-8. A “multi-user detector is coupled to the parameter estimator,” and “establish[es] estimates for the most probable digital

bits.” *Id.*, 12:59-62, 15:28-30. As shown in Figure 1, the output of the MUD feeds back to the parameter estimator to enable updated estimates in an iterative process, “until a fixed number of iterations is satisfied or a certain level of accuracy is achieved.” *Id.*, 15:30-35.

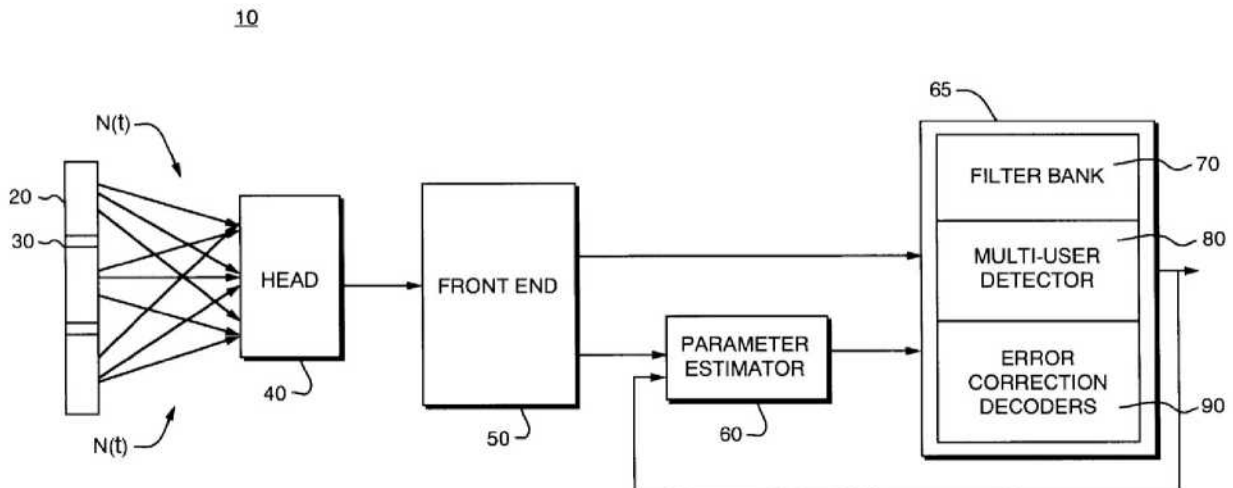


FIG. 1

Figure 8 of Brommer illustrates another implementation of Brommer’s system, in which a “synchronizer” performs the parameter estimation by “generat[ing] a track transfer function, including estimates of the pulse envelope for each track.” *Id.*, 25:54-67, 26:52-53. The synchronizer passes the parameter estimates to a “joint detector,” which provides updated estimates to the synchronizer, and also generates preliminary symbol estimates. *Id.*, 26:1-4. A code processor then updates the preliminary estimates and outputs symbol estimates. *Id.*, 26:5-9. The system “[i]terat[es] between the code processor and the joint detector ... to refine these estimates in a methodical way,” using a “well known ... iterative processing or

turbo MUD” procedure.” *Id.*, 26:9-12.

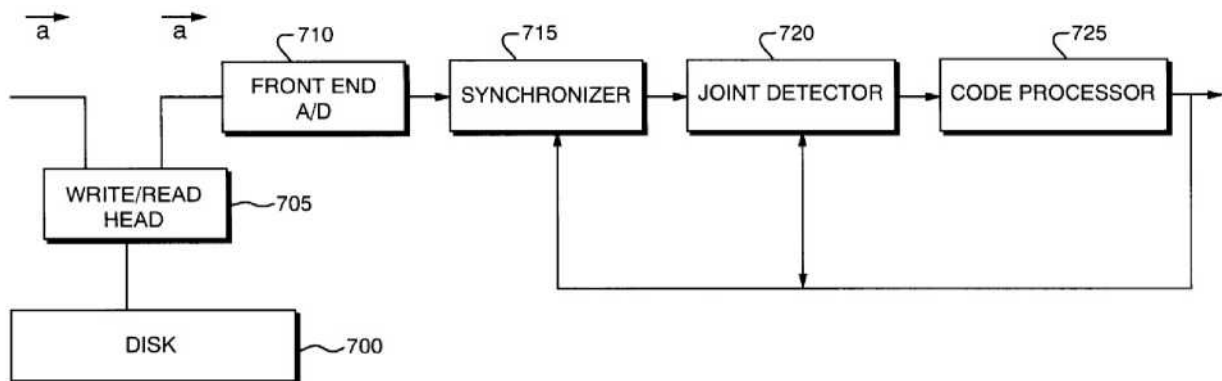


FIG. 8

Frank (Ex. 1006) is a 2001 Motorola patent publication that uses “interference cancellation for symbol determination” in “a CDMA communication system which has a plurality of code channels in use.” Ex. 1006, Abstract. A block diagram of an exemplary system is illustrated in Figure 1, reproduced below.

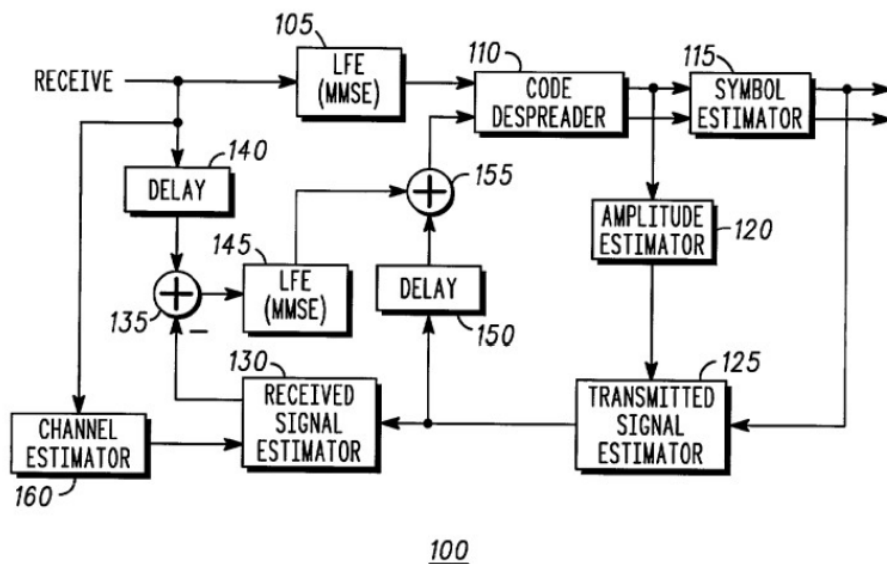


FIG. 1

In the preferred embodiment, “a plurality of symbol estimates” are determined for “all corresponding code channels,” each corresponding to a user. *Id.*, [0008]. “[A]n amplitude estimate for all [code] channels ... and a confidence measure for each symbol estimate ... are also determined.” *Id.* The symbol estimates and amplitude estimates are then used to perform interference cancellation on the original combined signal. *Id.*, [0009]. The process then repeats, iterating one or more additional times to provide successively better symbol estimates “until a desired level of accuracy is achieved.” *Id.*, [0010].

The ’703 patent adds nothing to this deep body of knowledge. The patent claims and describes the basic concepts of iterative MUD that were well-known at the time.

II. STANDING

Petitioners certify the ’703 patent is available for *inter partes* review and they are not estopped.

III. GROUNDS

Petitioners request review and cancellation of the claims based on the following grounds:

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

IV. POSITA

A POSITA at the time of the '703 patent would have had at least a bachelor's degree in electrical engineering, computer engineering, computer science, physics, or an equivalent field, and two years of experience with cellular telecommunications, radio-access network architectures and protocols, and signal propagation in wireless networks. Ex. 1003, ¶54. More education can supplement practical experience and vice versa. *Id.* Petitioners' expert exceeded this by the priority date. *Id.*, ¶55.

V. TECHNICAL BACKGROUND

The '703 patent relates to multi-user detection, or "MUD." MUD techniques have been known for decades, and documented since at least the 1980s. Ex. 1003, ¶34. Generally speaking, a MUD system allows users to transmit information over a shared communication path or channel. The users' information is transmitted as a data stream comprising interfering signals² over the shared communication path or

² Interfering signals are signals that suffer from interference from another signal that overlaps in amplitude, phase, frequency, or time. Interfering signals may include both unwanted noise and intentionally overlapping signals from multiple

channel. Allowing for interfering signals allows the communication channel to support a much higher capacity—otherwise, the channel would be limited to the number of users that can simultaneously transmit non-interfering signals (*i.e.*, by transmitting on distinct frequencies, or at different times).

Because the signals interfere with each other, though, the receiver in such a system must be capable of differentiating between the different intended signals within the data stream so that each individual user’s original transmission can be extracted. MUD attempts to detect the signal associated with each transmitting user by using parameters (e.g., amplitude, phase, code, and timing) related to each user to extract each user’s signal. *Id.*

One early description of MUD is in a paper by Sergio Verdu titled “Computational Complexity of Optimum Multiuser Detection,” *Algorithmica* (1989) (Ex. 1011). Ex. 1003, ¶35. Even by 1989, MUD was well-known for detecting signals for each user in a multi-user system. For example, Verdu described MUD using parameter estimating 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.” Ex. 1011, 304. Verdu’s optimal

users. Interference in a received signal causes the primary signal’s parameters to be obscured by the interfering signals.

multiuser detector was “much too complex” for many “practical” systems; however, by the 1990s, researchers had developed a number of different “suboptimal multiuser detector solutions which are more feasible to implement.” Ex. 1013 at 126; Ex. 1003, ¶42; see *also* Ex. 1001 at 6:40-44 (“[O]ptimal processing is a [sic] computationally complex and it is not possible to accomplish in a real-time environment.”).

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. Ex. 1003, ¶36. 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. For example, Qualcomm pioneered the use of Code-Division Multiple-Access (“CDMA”) technology in the 1990s. *Id.*, ¶37. In CDMA cellular networks, all users can transmit at the same time, and can use the entire available frequency spectrum for transmission. Ex. 1013 at 124. In order to differentiate users from each other, each user’s signal is multiplied by a “distinct code waveform” at the transmitter. *Id.* The receiver receives a data stream “composed of the sum of all users’ signals, which overlap in time and frequency,” and extracts each user’s signal

by “correlating the entire received signal with [a particular] user’s code waveform.”

Id.

Even in CDMA systems, however, randomness inherent in the system makes it impossible to eliminate interference between users entirely using the code waveforms. Ex. 1013 at 124. “While the [interference] caused by any one user is generally small, as the number of interferers or their power increases, [interference] becomes substantial.” *Id.* In conventional CDMA receivers, interference from other users would be treated as random noise, and conventional techniques for mitigating and accounting for noise on the communication channel would be employed. However, researchers soon realized that “a better detection strategy is one of multi-user detection (also referred to as joint detection or interference cancelation), where “information about multiple users is used jointly to better detect each individual *user*.” *Id.* In multi-user detection, other users’ signals are not treated as noise; instead, the receiver attempts to more intelligently detect other users’ signals and eliminate them from the joint signal in order to isolate a particular user’s signal.

By the mid-1990s, researchers developed multiple MUD techniques that could be used to further improve multi-user detection in CDMA systems and overcome interference between users. In general, these solutions could be classified into two categories of techniques: linear multi-user detectors and subtractive interference cancellation detectors. Ex. 1013 at 126; Ex. 1003, ¶42. Subtractive

interference cancellation is particularly relevant to the '703 patent and the Grounds described herein. In subtractive interference cancellation, the multi-user detector generates “separate estimates of the [interference] contributed by each user in order to subtract out some or all of the [interference] seen by each user.” Ex. 1013, 130; Ex. 1003, ¶43. Such detectors are often implemented to perform detection iteratively, with the output improving after each iteration. Ex. 1013, 130. For example, in successive interference cancellation, “[e]ach stage of [the] detector decisions, regenerates, and cancels out one additional ... user from the received signal, so that the remaining users see less [interference] in the next stage.” *Id.* In parallel interference cancellation, the detector “estimates and subtracts out all of the [interference] for each user in parallel.” *Id.* at 131. The process is “repeated for multiple stages,” each “tak[ing] as its input the data estimates of the previous stage and produc[ing] a new set of estimates at its output.” *Id.*

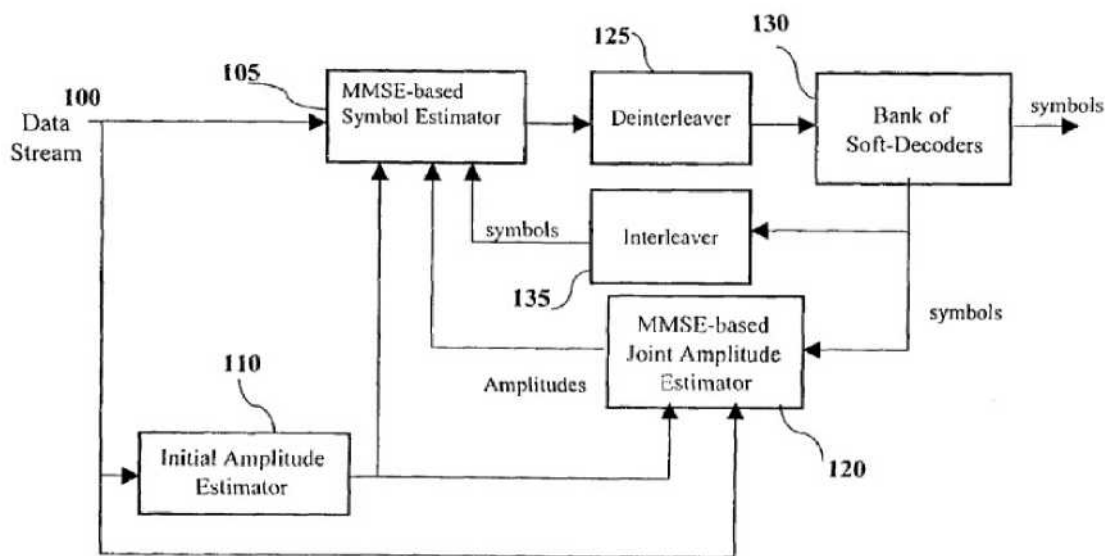
VI. OVERVIEW OF THE '703 PATENT

A. Disclosure

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. Indeed, the patent purports to be related to several applications expressly directed to multi-user detection systems. *Id.*, 1:9-18.

The '703 patent does not purport to invent MUD. To the contrary, the patent acknowledges that the prior art “describe[s] ... multiple user systems” where communications “are processed by a multi-user detector.” *Id.*, 5:8-11. The patent even admits that “[t]here are various multiuser detectors in the art.” *Id.*, 6:19-25. However, the '703 patent asserts that there are various disadvantages to existing multi-user detection schemes. For example, the '703 patent states that certain 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 also criticized for being “computationally complex” and “not possible to accomplish in a real-time environment.” *Id.*, 6:35-43. The '703 patent concedes that “[t]here are several suboptimal multiuser detectors that are less computationally complex and known in the art,” but asserts that even these systems “fail[] on 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 patent 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.

The '703 patent purports to improve on prior art multi-user systems by describing 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 depicts a “block diagram perspective ... for one embodiment of the invention.” *Id.*, 11:18-20.



In Figure 2, a received signal (*i.e.*, Data Stream 100) is communicated to a symbol estimator—depicted as an “MMSE-based Symbol Estimator,” but “other forms of symbol estimators ... are within the scope of the invention.” Ex. 1001, 14:58-15:3. The '703 patent recites a number of different prior art MUD techniques as options 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.

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.

The symbol estimates output from the symbol estimator are provided to “a bank of single user decoders,” which in turn output “symbol estimates and their respective likelihoods.” *Id.*, 16:3-6, 16:18-20. The estimates are also iteratively “fed back around” to both the symbol estimator and the joint amplitude estimator. *Id.*, 16:20-23. 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 then “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.

Other disclosed embodiments provide more details regarding the implementations of the elements depicted in Figure 2, but the detailed implementations are not claimed. Instead, the claims only recite the high-level

architecture shown in Figure 2, comprising an initial amplitude estimator, a joint amplitude estimator, a symbol estimator, and a bank of decoders.

B. Prosecution History

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. There were no substantive rejections or amendments before the claims were issued. Following the election of claims 1-5, the application that led to the '703 patent was allowed. *See generally* Ex. 1002.

VII. CLAIM CONSTRUCTION

For the purposes of this proceeding, Petitioners contend no claim terms need construction because the claims read on the prior art presented below under any construction consistent with *Phillips* and should thus be given their plain and ordinary meaning. Ex. 1003, ¶¶57-58.

VIII. CLAIMS 1-5 ARE UNPATENTABLE OVER THE PRIOR ART³

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

³ Petitioners are not aware of any secondary considerations of non-obviousness identified by Patent Owner, though none would rise to the level of overcoming the invalidity opinions of Dr. Min. Ex. 1003, ¶¶201-205. Petitioners reserve the right to address any secondary considerations if raised by Patent Owner.

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. 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 set forth below.

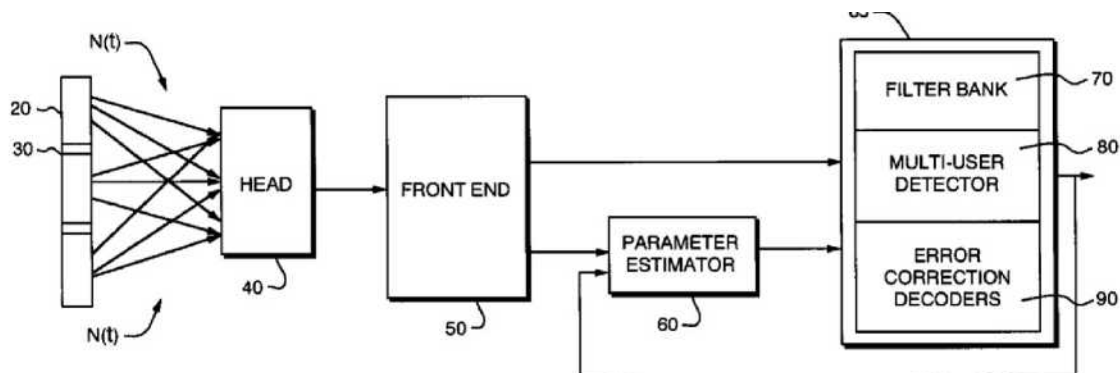
1. Brommer (U.S. Patent No. 6,826,140) (Ex. 1004)

Brommer claims priority to a U.S. patent application filed on August 26, 2002, published on February 26, 2004 as U.S. Pat. Pub. No. 2004/0037202, and issued on November 30, 2004. *See* Ex. 1004. Accordingly, Brommer is prior art to the '703 Patent under at least §102(e).

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. As part of Brommer’s processing scheme, 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.

Figure 1 of Brommer, reproduced below, illustrates one embodiment of Brommer’s multi-user detection apparatus. 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 track (*i.e.*, 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.



Brommer's Figure 8, reproduced below, also describes the system in terms of a "synchronizer 715" (instead of parameter estimator 60) 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 and code processor then generate preliminary and final symbol estimates, respectively. *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.

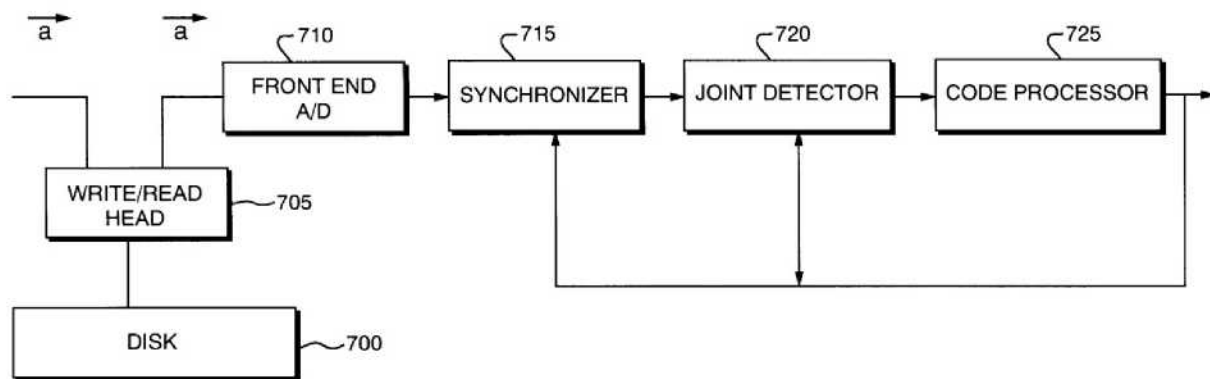


FIG. 8

2. Lilleberg (U.S. Patent No. 5,905,946) (Ex. 1007)

Lilleberg claims priority to a U.S. patent application filed on November 1, 1995, and issued on May 18, 1999. *See* Ex. 1007. Accordingly, Lilleberg is prior art to the '703 Patent under at least § 102(b).

Lilleberg discloses a “method of estimating a channel in which elimination of multiple access interference is taken into account.” Ex. 1007, 2:15-17. “The features of the channel that are estimated are usually the complex amplitude and the delay.” *Id.*, 3:25-26. Lilleberg specifically discloses using two different estimators to estimate these parameters: a first estimator “where preliminary channel estimation is conducted by a known estimation method,” and a second estimator “whereby more accurate estimates are obtained than in the first estimation means, which conduct the preliminary estimation.” *Id.*, 3:21-25, 3:31-38.

3. Hottinen (U.S. Patent No. 5,995,499) (Ex. 1009)

Hottinen claims priority to a PCT application filed on October 5, 1995, and issued on November 30, 1999. *See* Ex. 1009. Accordingly, Hottinen is prior art to the '703 Patent under at least §102(b).

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 iteratively 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.

4. Motivation to Combine

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. Ex. 1003, ¶¶83-89.

Although Lilleberg and Hottinen both relate to wireless communication systems, and not a digital media storage system like Brommer, 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. Ex. 1003, ¶84. Specifically, Brommer acknowledges 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, 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. Ex. 1003, ¶84.

In addition, Brommer expressly suggests looking to other references for parameter estimation techniques, and would have motivated a POSITA to look to references such as Lilleberg and Hottinen. Ex. 1003, ¶85. Brommer expressly 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, a POSITA would have been motivated to look outside of Brommer for implementation details and improvements relating to Brommer’s parameter estimator.

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. 1003, ¶86; Ex. 1004, Abstract (“Joint detection signal processing resolves the interference and data bits from the multiple sensed tracks.”). Further, Lilleberg 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. A POSITA would have 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. Lilleberg also 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.

A POSITA would have further been motivated to use a joint estimator as Lilleberg’s second estimation unit in view of Hottinen. Ex. 1003, ¶87. As noted above, Brommer only “*briefly*” describes its parameter estimator. Ex. 1004, 26:52-54. Lilleberg similarly teaches that parameter estimation in 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, a POSITA would have understood that Hottinen’s joint estimation method would be particularly beneficial in the combination with Brommer and Lilleberg, both of which are directed to systems affected by co-channel interference. Ex. 1003, ¶87.

A POSITA would have reasonably expected this combination to succeed. MUD had long been known in the field, and parameter estimation was a well-known step in MUD algorithms. Ex. 1003, ¶88. 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,” such as 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,” such as Hottinen’s joint estimation method. *Id.*, 3:36-38. A POSITA would have thus understood that Brommer, Lilleberg, and Hottinen are compatible. Ex. 1003, ¶88. 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. *Id.* A POSITA would have further understood that the references disclose interrelated teachings based on routine technologies and would have been amenable to various well-understood and predictable combinations. *Id.*

Finally, 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. 1003, ¶89; 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.”).

5. Claim 1

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

To the extent the preamble is limiting, Brommer discloses an apparatus that processes a digital data stream from multiple users—*i.e.*, multiple interfering tracks of a storage device. Ex. 1003, ¶¶90-94. 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 [*i.e.*, a digital data stream from multiple users].” Ex. 1004, 12:49-52. Specifically, Brommer discloses 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.

Brommer does not disclose that different tracks are associated with a different user in a communication network, but the '703 patent expressly states 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. As noted above, each of Brommer’s tracks is a separate reference that stores and supplies digital data. Ex. 1003, ¶93.

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

Brommer discloses a “parameter estimator” that functions as an initial amplitude estimation unit that processes the digital data stream and produces initial amplitude estimates on the first iteration of multi-user detection. Ex. 1003, ¶¶95-103. Brommer’s parameter estimator is shown in Figure 1, annotated below. As illustrated, it receives the digital data stream from a front end unit and passes parameter estimates to the multi-user detector. Brommer explains that the front end unit “process[es] the electrical signals and convert[s] the electrical signals into a plurality of digital bits [*i.e.*, a digital data stream].” Ex. 1004, 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.

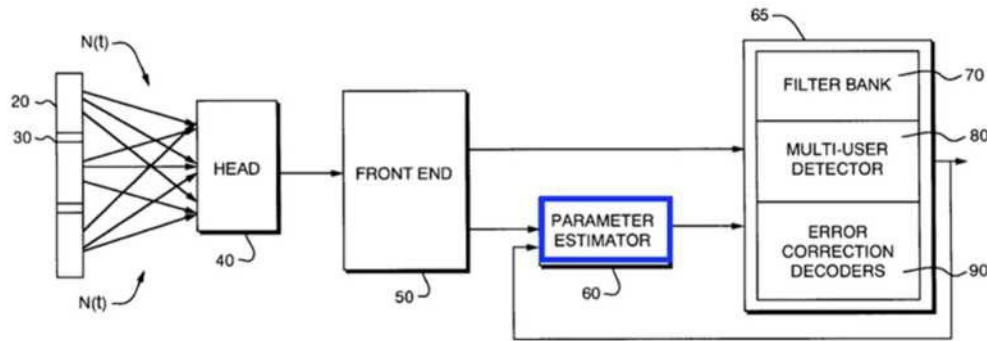
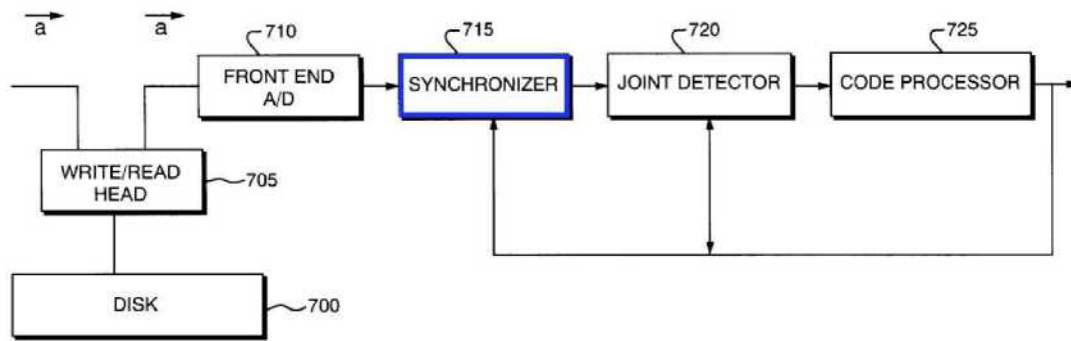


Figure 8, reproduced and annotated below, provides additional detail regarding the implementation of Brommer's system, and confirms that the parameter estimator produces initial amplitude estimates on a first iteration of a multi-user detection algorithm. Ex. 1003, ¶¶98-99. In Figure 8, the parameter 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.").



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. Ex. 1003, ¶100.

To the extent Patent Owner argues Brommer does not disclose that its parameter estimator produces initial amplitude estimates, it would have been obvious to a POSITA to generate initial amplitude estimates using Brommer's parameter estimator in view of Lilleberg. Ex. 1003, ¶101. Lilleberg specifically 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.

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 provided in Section VIII.A.4 above.

- (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”**

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 further discloses that the synchronizer and joint detector together perform parameter estimation. *Id.*, 26:27-36. However, Brommer does not expressly disclose producing updated amplitude estimates.

As discussed above for Limitation 1[a], 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,” whereby the second estimation means produces “more accurate estimates” than the first estimation means); Ex. 1003, ¶¶104-106.

Lilleberg does not expressly disclose that its second estimation unit is a *joint* amplitude estimator. However, it would have been obvious to a POSITA in view of Hottinen to use joint estimation for Lilleberg's second estimation means. Ex. 1003, ¶¶107-108. Lilleberg expressly 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").

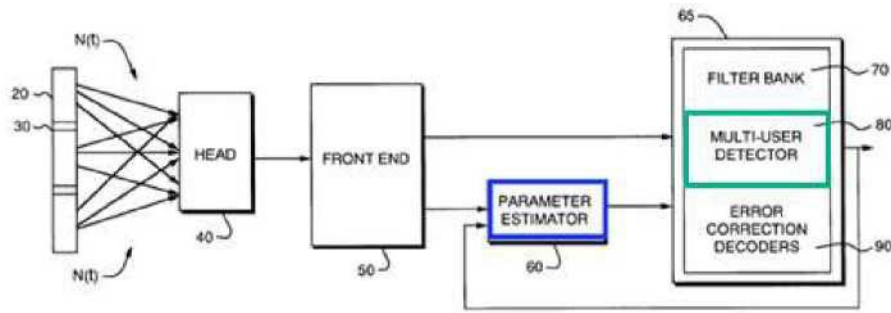
A POSITA would have been motivated to apply Lilleberg's teachings regarding first and second estimation means to Brommer's system, and to further use a joint channel estimation method as taught by Hottinen for Lilleberg's second estimation means, and would have reasonably expected to be successful in doing so, for the reasons provided in Section VIII.A.4 above.

In the proposed combination, the joint amplitude estimator (*i.e.*, the second estimation means as taught by Lilleberg, implementing a joint estimation method as taught by Hottinen) would be coupled to the data stream. Ex. 1003, ¶109. Lilleberg teaches that after initial interference cancellation, "the received transmission" (*i.e.*, the data stream) "is supplied to a second estimation means," where "the channel parameters are re-estimated." Ex. 1007, 4:1-9; see *also* Ex. 1001, 19:47-51

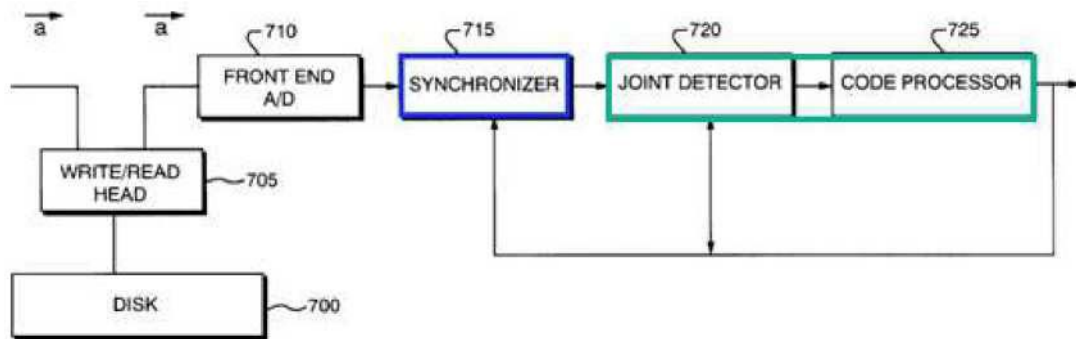
(explaining that “[p]rior to the application of the MMSE filter” in the joint amplitude estimator, as shown in Fig. 4, “interference cancellation is performed”). The joint amplitude estimator would also be coupled to the initial amplitude estimator (*i.e.*, Brommer’s parameter estimator/synchronizer). Ex. 1003, ¶110. 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.

- (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”

Brommer discloses a multi-user detector that “uses an algorithm to establish estimates for the most probable digital bits,” *i.e.*, **symbol estimates**. Ex. 1004, 15:28-29; Ex. 1003, ¶¶112-117. As shown in Figure 1, annotated below, the multi-user detector (*i.e.*, **symbol estimator**) is coupled to the **data stream** (received from the front end) and Brommer’s parameter estimator (*i.e.*, the **initial amplitude estimator**). Ex. 1004, Fig. 1.



In Figure 8, the multi-user detector (**symbol estimator**) is represented 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; Ex. 1003, ¶114. The joint detector and code processor are coupled to the synchronizer (**initial amplitude estimator**), as shown in Figure 8, and to the received signal, as discussed above (the **data stream**).



In both examples, the multi-user detector produces symbol estimates for each user iteratively. Ex. 1004, 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, across the plurality of iterations, a plurality of symbol estimates will be produced for each user. Ex. 1003, ¶115.

As discussed for Limitation 1[b], in the proposed combination with Lilleberg and Hottinen, a **joint amplitude estimator** (*i.e.*, a second estimation means as taught by Lilleberg, applying a joint estimation method as taught by Hottinen) is added to Brommer’s system and is coupled to the initial amplitude estimator (*i.e.*, Brommer’s parameter estimator/synchronizer). *See* Limitation 1[b]; Ex. 1003, ¶116. The joint amplitude estimator is also coupled to the symbol estimator (*i.e.*, the multi-user detector or the joint detector and code processor) in the proposed combination. Ex. 1003, ¶116. Brommer expressly 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, a POSITA would have been motivated to combine the references with a reasonable expectation of success.

(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.”

Brommer discloses a “bank of decoders 90.” Ex. 1004, 15:28-30; Ex. 1003, ¶¶118-122. As shown in Figure 1 and described in the accompanying text, the bank of decoders are coupled to the multi-user detector, and receive “estimates for the most probable digital bits” (*i.e.*, symbol estimates) from the multi-user detector. Ex. 1004, 15:28-30; 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 further teaches that in a “soft output” system, the decoder output “indicate[s] both the discrete estimate and *the probability that the estimate is correct*” (*i.e.*, symbol likelihood estimates). *Id.*, 28:58-63.

The process “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. A POSITA would have understood that the “data” referenced includes the symbol likelihood estimates, which are **iteratively fed back** to the multi-user detector as described above until a **final condition** (e.g., fixed number of iterations or certain level of accuracy) is

reached. Ex. 1003, ¶120. 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. *Id.*

A POSITA would have understood that in the combined system, applying the teachings of Lilleberg and Hottinen as described in Limitations 1[a] and 1[b], the **symbol likelihood estimates** would also be **iteratively fed back** to the **joint amplitude estimator** (*i.e.*, second estimation means as taught by Lilleberg, applying a joint estimation method as taught by Hottinen). 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); Ex. 1003, ¶121. Lilleberg further teaches that estimation may “utiliz[e] the received bit estimates.” Ex. 1007, 5:10-15.

6. **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.”**

Brommer discloses that symbol estimates are iteratively fed back to the multi-user detector until a final condition is reached, including a fixed number of iterations. Ex. 1003, ¶¶123-125. Specifically, with respect to 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”).

7. **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 decisionfeedback 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.”**

Brommer discloses a symbol estimator from among the group recited in Claim 3. Ex. 1003, ¶¶126-128. Brommer discloses that the 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 then updated iteratively between the code processor and joint detector, using an iterative MUD technique. *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 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”).

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

Brommer, Lilleberg, and Hottinen disclose and render obvious claims 1-3, as discussed in Ground 1. 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. Learned (U.S. Patent No. 7,190,743) (Ex. 1005)

Learned was filed July 29, 2002, and published January 29, 2004. Accordingly, Learned is prior art to the '703 Patent under at least §102(e).

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 an exemplary embodiment, illustrated in Figure 4 and reproduced below, 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 of Figure 4 is specifically intended to be compatible with and used in 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.

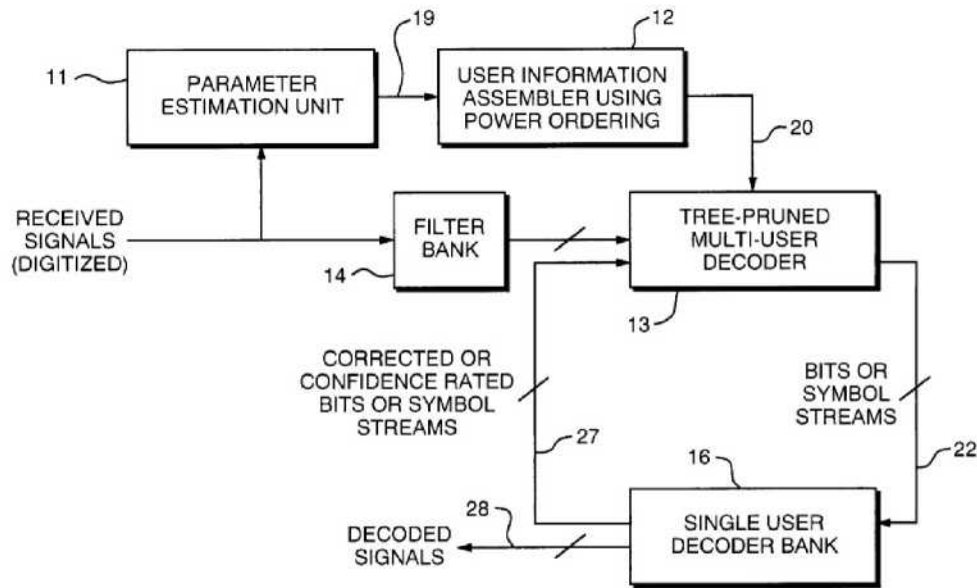


FIG. 4

2. Motivation to Combine

A POSITA would have been motivated to apply Learned's energy detection techniques to Brommer's MUD receiver. Ex. 1003, ¶¶131-135.

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. Thus, 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. Ex. 1003, ¶132.

Brommer also provides express motivation to add tree-pruning, such as the tree-pruning technique taught by Learned, to its system. Brommer expressly recognizes, in describing the possible implementations of the multi-user detection of Figure 8, 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 acknowledges that prior art tree-pruning techniques may encounter problems where “improper pruning” must be accounted for by increasing complexity. *Id.*, 28:34-39. Accordingly, a POSITA would have been motivated to apply Learned’s power-ordered tree-pruning technique, which substantially reduces the incidence of such “improper pruning.” Ex. 1003, ¶133.

A POSITA would have reasonably expected this combination to succeed. Ex. 1003, ¶134. Brommer acknowledges that tree-pruning was a well-known technique that had long been used in the field. Ex. 1004, 28:12-40. A POSITA would thus have been familiar with its implementation in a MUD receiver and capable of implementing it in Brommer’s system, particularly since Brommer expressly

identifies “tree-pruning based MUD” as an option available for use within its system. Further, Learned expressly teaches how to use the results of parameter estimation (e.g., as performed by Brommer’s parameter estimator or synchronizer) to perform power ordering of user signals in order to enhance conventional tree-pruning implementations. Ex. 1003, ¶134. 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 the same within Brommer. *Id.*

Finally, 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. 1003, ¶135; 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.”). Additionally, Brommer and Learned were both developed by and originally assigned to BAE Systems around the same time.

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

It would have been obvious to a POSITA to include an energy detector coupled to the joint amplitude estimator in the Brommer/Lilleberg/Hottinen system in view of Learned. Ex. 1003, ¶¶136-139. 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. 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. Ex. 1003, ¶137. 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.* As discussed above, a POSITA would have been motivated to combine the references with a reasonable expectation of success.

In the proposed combination, the energy detector would be included in Brommer's parameter estimator or synchronizer, 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 discussed in Ground 1 for Limitation 1[b], in the combination with Lilleberg and Hottinen, Brommer's parameter estimator and synchronizer are coupled to the joint amplitude estimator. Accordingly, the energy detector as taught by Learned would also be coupled to the joint amplitude estimator in the combined system. Ex. 1003, ¶138.

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

Brommer, Lilleberg, and Hottinen disclose and render obvious claims 1-3, as discussed in Ground 1. ElGamal similarly discloses a multi-user detection scheme, but further identifies several well-known decoding algorithms that may be used in the bank of decoders. As set forth below, it would have been obvious to a POSITA to combine the references.

1. ElGamal (U.S. Patent No. 6,898,248) (Ex. 1008)

ElGamal claims priority to a U.S. provisional application filed on July 12, 1999, and issued on May 24, 2005. Accordingly, Elgamal is prior art to the '703

Patent under at least §102(e).

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.

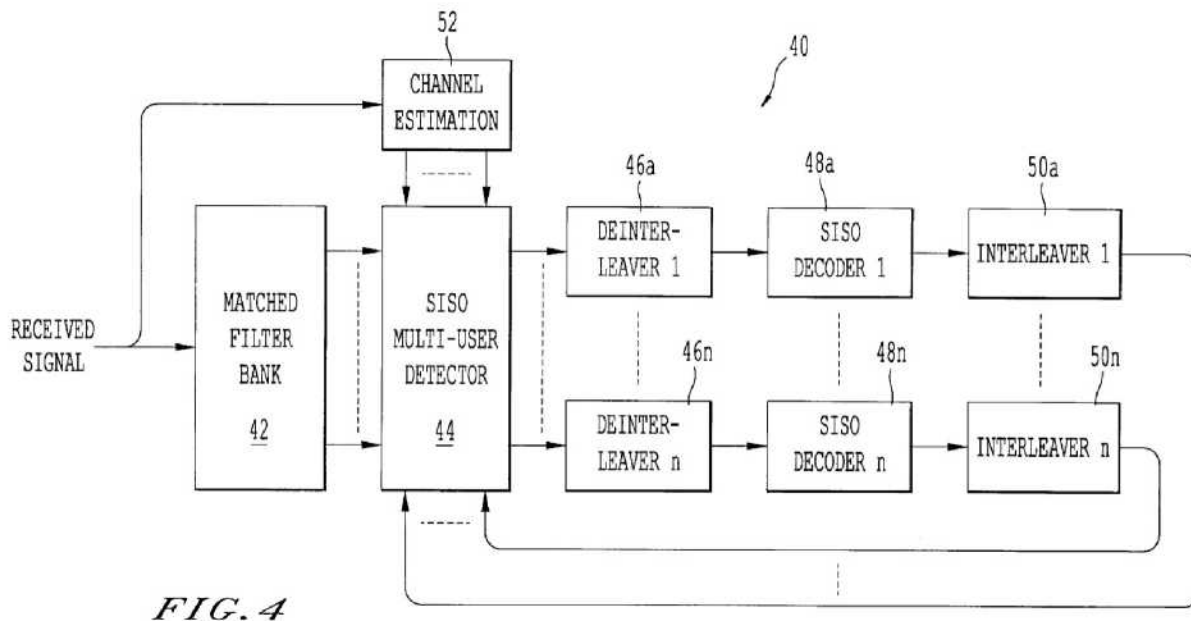


FIG. 4

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.

2. Motivation to Combine

A POSITA would have been motivated to apply ElGamal’s decoding algorithms to Brommer’s receiver for processing multi-user signal streams. Ex. 1003, ¶¶142-147.

Although ElGamal relates to a wireless communication system, and not a digital media storage system like Brommer, Brommer provides a motivation to look

to multi-user detection techniques used in other applications, as discussed above. *See* Section VIII.A.4; Ex. 1003, ¶143; Ex. 1004, 15:33-35.

Brommer discloses a bank of decoders (see Ground 1, Limitation 1[d]) but does not specify the decoding algorithm(s) used. Brommer discloses that multi-user detector can employ an algorithm “based upon MAP, Log-MAP, or Max-Log MAP detectors,” but does not specifically indicate that its *decoders* implement that algorithm. Ex. 1004, 13:31-33; *see also id.*, 5:47-48 (“The decoder implements a decoding algorithm to generate the digital data signal.”). A POSITA would have understood that any known decoding algorithm may be used in Brommer’s system. Ex. 1003, ¶144.

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, “channel decoders ... associated with the component channel codes.” *Id.*, 9:8-14. Unlike Brommer, however, ElGamal discloses 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 that the choice “depends on the available processing power at the receiver.” *Id.*, 9:26-34. 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, as they would have been suitable to solve the same problem in Brommer's system, *i.e.*, decoding the received data stream. Ex. 1003, ¶145.

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. Ex. 1003, ¶146. 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, a POSITA would have understood that at least MAP and log-MAP decoders would be compatible with Brommer's system. Ex. 1003, ¶146. 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. *Id.*

Finally, 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. 1003, ¶147; Ex. 1001, 1:24-27; Ex. 1004, 10:62-65; Ex. 1007, Abstract; Ex. 1009, 1:9-15; 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.").

3. 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.”

Brommer and ElGamal render obvious selecting the decoders from among Soft-output Viterbi, Maximum A Posteriori (MAP), and Bahl-Cocke-Jelinek-Raviv. Ex. 1003, ¶¶148-151. 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 the MAP algorithm, and otherwise only generally states that “[t]he decoder implements a decoding algorithm to generate the digital data signal.” *Id.*, 5:47-48. However, 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. Ex. 1003, ¶149.

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 discussed above, a POSITA would have been motivated to combine the references with a reasonable expectation of success. Ex. 1003, ¶150.

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

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 set forth below, it would have been obvious to a POSITA to apply Zha's teachings to Frank.

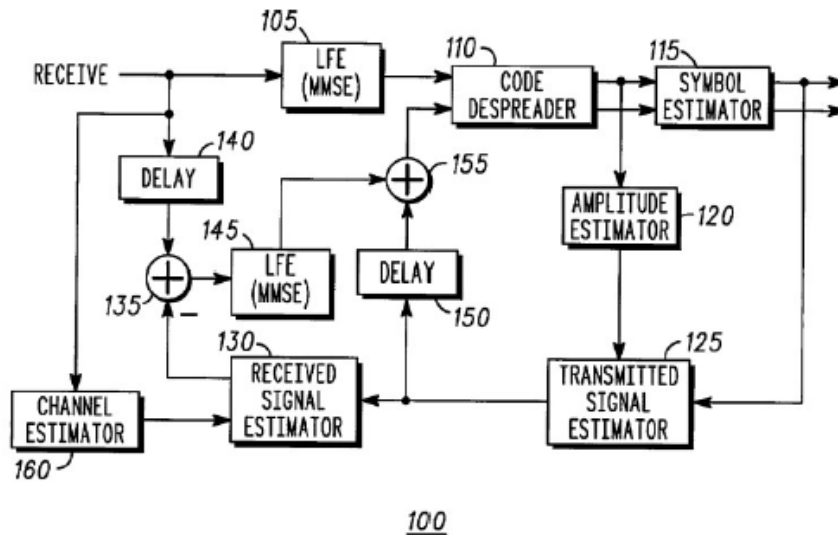
1. Frank (U.S. Patent Pub No. 2003/0035469) (Ex. 1006)

Frank was filed on August 20, 2001 and published on February 20, 2003. Accordingly, Frank is prior art to the '703 Patent under at least §102(a).

Frank is a Motorola patent publication 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].

Frank discloses a system for interference cancellation, using an amplitude estimator, symbol estimator, and transmitted signal estimator as part of a feedback loop. *Id.*, [0018]-[0022]. Amplitude estimates are used to "weight[] each estimated symbol" and "sum[] the result," and "produce an estimated transmitted signal." *Id.*, [0020]. The estimated received signal is used in interference cancellation by subtracting it from the received signal for generating updated symbol estimates. *Id.*,

[0022]. An embodiment of Frank's system is illustrated in Figure 1, reproduced below.



2. Zha (“Soft-Decision Successive Interference Cancellation CDMA Receiver with Amplitude Averaging and Robust to Timing Errors”) (Ex. 1010)

Zha is a paper that was presented at the IEEE Global Telecommunications Conference 2001 (GLOBECOM '01), which took place from November 25 to 29, 2001. Zha was also published in the Proceedings of GLOBECOM '01, published by IEEE in 2001 and made available on IEEE Xplore in August 2002. Accordingly, Zha is prior art to the '703 Patent under at least §102(a)-(b).

As discussed by Dr. Min, Exhibit 1010 is a true and correct copy of Zha as published by IEEE on the IEEE Xplore website. Ex. 1003, ¶74. Zha on its face bears a publication date of 2001. Dr. Min opines that this date, which is further corroborated by the date on IEEE Xplore's website, is a highly reliable indicator of

public availability. *Id.*, ¶¶73-74. In addition, the IEEE Xplore website itself indicates that the paper was uploaded to and made available on IEEE Xplore by August 2002. *Id.*; see also IPR2014- 00527, Paper 41 at 11 (“IEEE is a well-known, reputable compiler and publisher of scientific and technical publications, and we take Official Notice that members in the scientific and technical communities who both publish and engage in research rely on information published on the copyright line of IEEE publications.”).

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.

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.*

3. Motivation to Combine

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. Ex. 1003, ¶¶154-157.

Frank expressly teaches 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). Ex. 1003, ¶154. Specifically, 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.* These express teachings would motivate a POSITA to apply Zha’s improvements using amplitude averaging and decision rules to Frank’s system using successive interference cancellation in order to achieve similar, predictable

improvements in Frank's CDMA receiver. Ex. 1003, ¶154. Further, Zha's improvements are complementary to those proposed by Frank. *Id.* Frank improves on conventional interference cancellation by adding linear MMSE equalization. Ex. 1006, [0007]. Zha provides a further improvement on top of Frank's linear MMSE equalization by adding amplitude averaging and improved bit decision rules to further improve performance. Ex. 1003, ¶154.

A POSITA would have reasonably expected this combination to succeed. Successive interference cancellation was well known in the field prior to the '703 patent. Ex. 1003, ¶155. Zha discloses specific improvements to well-known successive interference cancellation techniques, which a POSITA could have readily applied to the particular receiver disclosed by Frank. *Id.* Implementing Zha's improvements in Frank's system would have been well within the capabilities of a POSITA. *Id.*

Finally, 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. 1003, ¶156; 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.”).

4. Claim 1

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

To the extent the preamble is limiting, Frank discloses “receivers for code division multiple access (CDMA) communication systems.” Ex. 1006, [0001]. CDMA communication systems include digital data streams from multiple users. Ex. 1003, ¶¶158-160. Indeed, Frank explains that CDMA systems have “multiple users plus noise in the channel.” Ex. 1006, [0005]; *see also id.*, [0007] (describing how the invention enables “increasing the number of users who may be served”). Frank’s receivers receive and process a signal in a CDMA communication system, which is a **digital data stream from multiple users**. *Id.*, [0007], [0018]; *see also id.*, [0048]-[0049] (discussing implementation of the system on a “processor” or group of processing elements), [0052] (describing the system as performing “ongoing processing of the received signal”).

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

Frank discloses an “amplitude estimator” that performs **initial amplitude estimation**. Ex. 1006, [0019], Fig. 1. The amplitude estimator receives as input the filtered and despread received signal (*i.e.*, the **data stream**) and determines “an amplitude estimate for all corresponding channels of the plurality of channels,” *i.e.*, for each user. *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.”); Ex. 1003, ¶¶161-164.

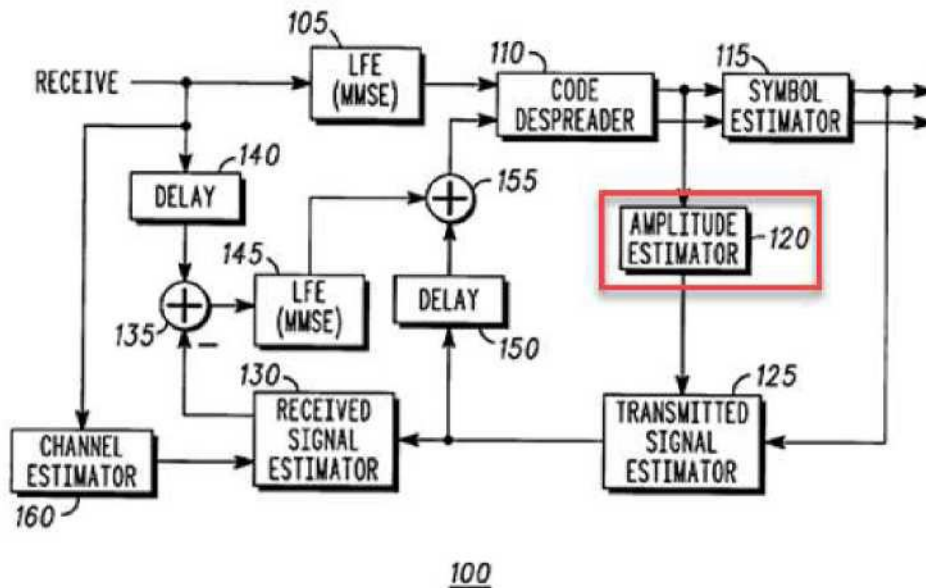
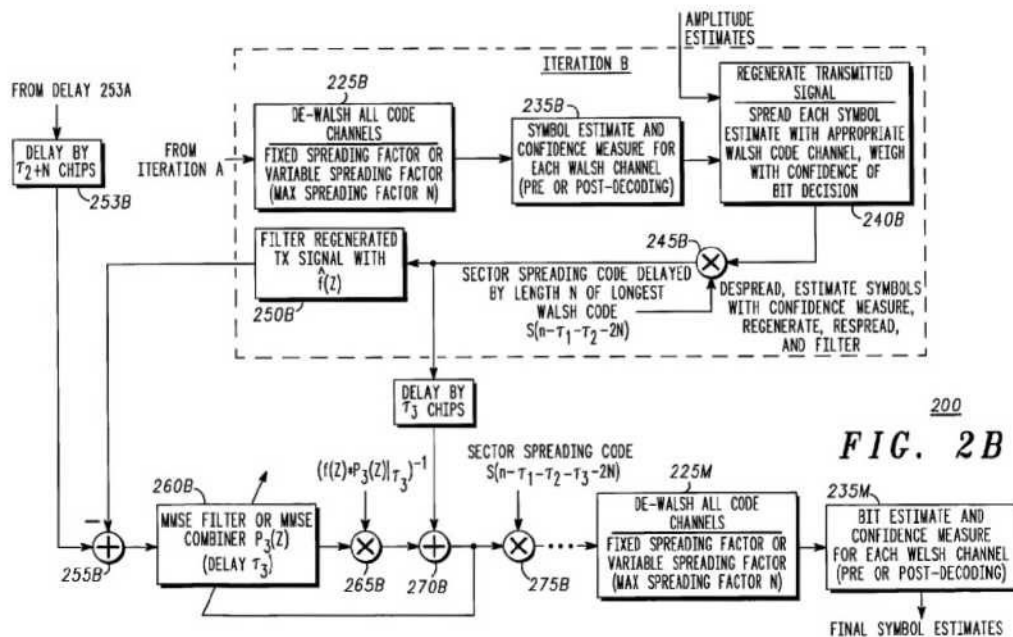
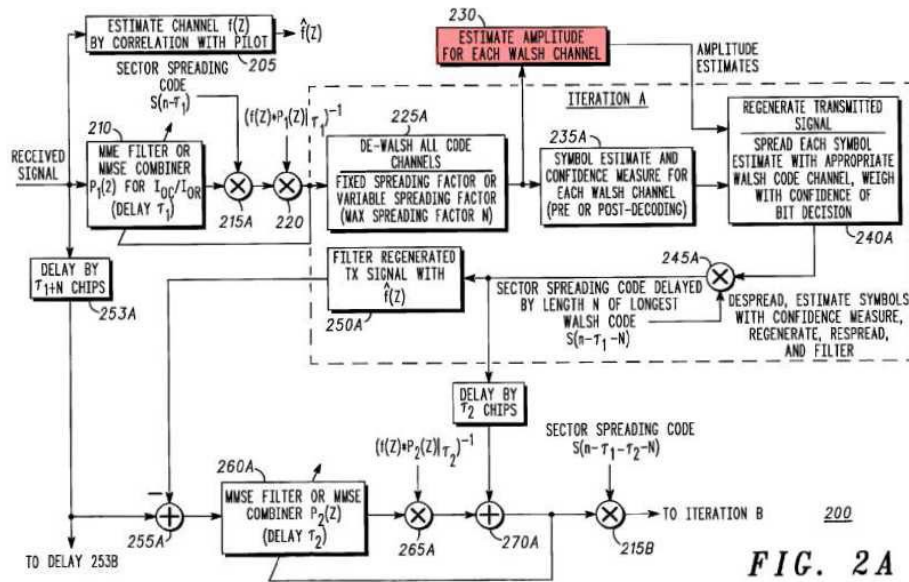


FIG. 1

As illustrated in Figures 2A and 2B, Frank’s amplitude estimator performs an **initial amplitude estimation**: it determines amplitude estimates during a **first iteration** (“Iteration A”), but not in subsequent iterations (e.g., “Iteration B”). Ex. 1006, Figs. 2A, 2B; Ex. 1003, ¶163.



(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”

Frank does not expressly disclose a joint amplitude estimator that produces updated amplitude estimates. However, it would have been obvious to a POSITA

to use a joint amplitude estimator that produces updated amplitude estimates in Frank's system in view of Zha. Ex. 1003, ¶¶165-171.

Zha discloses a "SIC [successive interference cancellation] receiver with amplitude averaging" that "has multiple interference cancellation stages, starting from stage $v = 1$." Ex. 1010, 744. "During the $(v+1)$ st stage"—*i.e.*, in each iteration after the initial 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.* The averaged amplitude estimates are **joint amplitude estimates** as described in the '703 patent. Ex. 1003, ¶167. For example, the '703 patent explains that the 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 similarly process " $(M + 1)$ observation intervals" by "averaging [*i.e.*, combining] the instantaneous estimate of" a given user's individual "amplitudes over a block of M bits." Ex. 1010, 744; Ex. 1003, ¶167. The process disclosed by Zha **produces updated amplitude estimates** because it is repeated at each stage (iteration) of the receiver after the first, and re-estimates the amplitudes based on the previous iteration of interference cancellation. Ex. 1010, 744; Ex. 1003, ¶167.

In the combined system, the joint amplitude estimator as taught by Zha would be **coupled to the data stream and the initial amplitude estimator**. Ex. 1003,

¶¶168-170. The joint amplitude estimator is coupled to the data stream because Zha's averaged amplitude estimation requires as input each user's estimated received signal, which is based on the original received signal. Ex. 1010, 744; Ex. 1003, ¶168. The joint amplitude estimator of the '703 patent receives a similar estimated received signal as an input and uses it to compute amplitude estimates. Ex. 1001, 19:47-67; Ex. 1003, ¶169. The joint amplitude estimator is also coupled to the initial amplitude estimator because each iteration after the first relies on the previous iteration's amplitude estimates to produce updated amplitude estimates. Ex. 1010, 744; Ex. 1003, ¶170. Thus, in the second iteration, the joint amplitude estimator must receive and use the amplitude estimates from the first iteration, *i.e.*, the initial amplitude estimates from the initial amplitude estimator. Ex. 1003, ¶170,

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 provided in Section VIII.D.3 above.

- (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”

Frank discloses a “symbol estimator 115, which produces an output stream consisting of symbol estimates or (soft) symbol decisions.” Ex. 1006, [0019]; *see*

also id., [0008]. Symbol estimates are determined for “each code channel” (*i.e.*, **each user**). *Id.*, [0032]; *see also id.*, Fig. 2 (element 235A); Ex. 1003, ¶¶173-176.

As shown in Figure 1, the symbol estimator 115 is coupled to the received signal after filtering and despreading (*i.e.*, the **data stream**), which is also the input to the initial amplitude estimator. Ex. 1006, Fig. 1. As shown in Figure 1, the symbol estimator is also coupled to the amplitude estimator 120 (the **initial amplitude estimator**). *Id.*, Fig. 1. In addition, Frank discloses that reliability estimates, which are produced by the symbol estimator for each symbol estimate, may be calculated using “the amplitude estimate for the given code channel.” *Id.*, [0032]-[0033]. The symbol estimator would thus have to be coupled to the initial amplitude estimator in order to receive the amplitude estimates used to generate the reliability estimates. Ex. 1003, ¶175.

For the same reason, in the combined system, the averaged amplitude estimates as taught by Zha (*i.e.*, the **joint amplitude estimator**) would be coupled to the symbol estimator, so that the updated amplitude estimates may be used to generate reliability estimates in each iteration after the first. Ex. 1003, ¶175.

- (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.”

Frank does not expressly disclose a bank of decoders that produce symbol likelihood estimates for each user. However, it would have been obvious to a POSITA to provide a bank of decoders for producing symbol likelihood estimates for each user in Frank's system in view of Zha. Ex. 1003, ¶¶177-181.

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. A POSITA would have understood that the "decision rule" corresponds to a decoder, and that Zha thus discloses a plurality of decoders, one **for each user's** data bit decision (*i.e.*, a **bank of decoders**). Ex. 1003, ¶178. In the combined system, Zha's decoders would be **coupled to Frank's symbol estimator**, because the symbol estimates (*i.e.*, the soft data bit estimates) are the input to the decoders. *Id.*

Zha further discloses that the "decision rule" is a "soft bit decision rule." Ex. 1010, 744. A POSITA would have understood that a soft bit decision rule produces symbol likelihood estimates. Ex. 1003, ¶179. In addition, the symbol likelihood estimates are used in the subsequent iteration to perform interference cancellation for each user. Ex. 1010, 744; Ex. 1003, ¶179. Thus, the symbol likelihood estimates are iteratively fed back to the joint amplitude estimator and symbol estimator after each iteration. Ex. 1003, ¶179. Zha further teaches that the process "terminate[s] after a desired number of cancellation stages" (*i.e.*, a final condition). Ex. 1010, 744; Ex. 1003, ¶180.

A POSITA would have been motivated to apply Zha's teachings regarding soft bit decision rules to Frank's system, and would have reasonably expected to be successful in doing so, for the reasons provided in Section VIII.D.3 above.

5. 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."

As discussed above for Limitation 1[d], in the combined system, Zha's decision rules (*i.e.*, **bank of decoders**) iteratively feed back data bit decisions (*i.e.*, **symbol likelihood estimates**), and "terminate[]" after a desired number of cancellation stages" (*i.e.*, a **fixed number of iterations**). Ex. 1010, 744; Ex. 1003, ¶183. Frank similarly teaches performing interference cancellation until "an iteration limit has been exceeded." Ex. 1006, [0042].

6. 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 decisionfeedback 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."

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, as Zha’s improvements are particularly beneficial for successive interference cancellation. Ex. 1003, ¶186.

7. 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.”

Frank discloses that decoders selected from at least the Soft-output Viterbi algorithm. Ex. 1003, ¶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 also expressly identifies the “**soft-output Viterbi algorithm**” is “one such algorithm for trellis codes.” *Id.*

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

Frank and Zha disclose and render obvious claims 1-3 and 5, as discussed in 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

A POSITA would have been motivated to apply Learned's energy detection techniques to Frank's receiver. Ex. 1003, ¶¶193-197.

As discussed in Ground 2, Learned provides express motivations to add tree-pruning to a multi-user detector in a receiver, such as Frank's. *See* Section VIII.B.2; 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, 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. Ex. 1003, ¶194.

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 with 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, a POSITA would have been motivated to apply Learned's power-ordered tree-pruning technique, which

reduces complexity while also minimizing degradation of performance. Ex. 1003, ¶195.

A POSITA would have reasonably expected this combination to succeed. Ex. 1003, ¶196. Tree-pruning was a well-known technique that had long been used in the field, and a POSITA would have been familiar with its implementation in a MUD receiver and capable of implementing it in Frank's system. Further, 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. Ex. 1003, ¶196. 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. *Id.*

Finally, 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. 1003, ¶197; Ex. 1006, [0001], [0005], [0023] (discussing trade-offs between complexity and performance); Ex. 1010, 743; Ex. 1001, 1:24-27; 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.").

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

It would have been obvious to a POSITA to include an energy detector coupled to the joint amplitude estimator in the Frank/Zha system in view of Learned. Ex. 1003, ¶¶198-200. As discussed 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. 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. Ex. 1003, ¶199. 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.*

IX. THE BOARD SHOULD NOT EXERCISE ITS DISCRETION TO DENY INSTITUTION

A. *Fintiv*

The Board balances six factors in considering discretionary denial under 35 U.S.C. § 314(a) when parallel litigation exists. *Apple Inc. v. Fintiv, Inc.*, IPR2020-

00019, Paper 11 (PTAB Mar. 20, 2020) (precedential). To the extent the Board institutes the Samsung IPR that Petitioners seek to join, *Fintiv* is not relevant. If the Board were to consider Petitioners’ petition in the first instance, the *Fintiv* factors would favor institution.

Factor 1—potential stay of the district court litigation—is neutral because Lenovo Group Limited (“Lenovo”), the defendant in the district court, has not requested a stay. *VMWare, Inc. v. Intellectual Ventures I LLC*, IPR2020-00470, Paper 13 (PTAB Aug. 18, 2020), at 17 (finding in the absence of a stay motion that this factor “does not weigh for or against discretionary denial”).

Factor 2—district court trial date and the Board’s statutory deadline—weigh against denial. The Guidance Memo states that this factor weighs against denial “if the median time-to-trial is around the same time or after the projected statutory deadline for the PTAB’s final written decision.” Ex. 1016. This petition is filed in December 2024, so a final written decision would likely issue by June 2026. The median time-to-trial in the Eastern District of Texas is 22 months. Ex. 1015. Although the Complaint against Lenovo was filed on December 12, 2023, the Complaint was not served until April 29, 2024. This unusually long delay in serving the Complaint has already once pushed back all case deadlines because the response date to a Complaint is based on the date of service, *see* Fed. R. Civ. P. 12(a), and Judge Gilstrap does not hold a scheduling conference until after there has been a

response to the Complaint, *see* Standing Order Regarding Readiness for Scheduling Conference, Ex. 1017. The four-month delay in service combined with the 22-month time-to-trial statistic results in a likely February-March 2026 trial date. The date currently set for jury selection—January 5, 2026, Ex. 1018—does not support denial where, as here, it is close in time to the final written decision, and the time-to-trial statistics and other evidence suggest that additional delays are likely. *See Dish Network v. Broadband iTV*, IPR 2020-01280, Paper 17 at 16 (PTAB Feb. 4, 2021) (“We cannot ignore the fact that the currently scheduled trial date is more than nine months away and much can change during this time”).

Factor 3—investment in the district court proceedings—weighs heavily against discretionary denial. The associated district court case is still in the very early stages of litigation. Because Lenovo, a Chinese company, has challenged the district court’s personal jurisdiction, the parties have been engaged in jurisdictional discovery, with the court’s jurisdictional authority still to be decided. Even if the court has personal jurisdiction over Lenovo, a claim construction hearing is not scheduled until July 15, 2025, so a claim construction order will not issue prior to the PTAB’s projected institution decision date in June 2025. Ex. 1018. Fact discovery will still be open, and dispositive motions and expert reports will be months away. *Id.* Accordingly, the district court will not invest significant resources

or issue substantive orders related to the challenged patent prior to the issuance of an institution decision. *See Fintiv*, IPR2020-00019, Paper 11 at 9-12.

Factor 4—overlap in the parallel proceedings—is neutral. Petitioners acknowledge that the grounds of invalidity asserted here are also asserted in the district court. But if “the Board will address the overlapping validity issues prior to the district court reaching them at trial, the Board’s final written decision will simplify or fully resolve the issues for trial in the litigation,” which weighs in favor of institution. *GAF Materials LLC v. Kirsch Rsch. and Dev., LLC*, IPR2021-00192, Paper 14 at 14–15 (PTAB May 25, 2021).

Factor 5—overlapping parties—is neutral because while the petitioners are different from the named defendant, Lenovo (United States) and Motorola Mobility LLC manufacture the accused products at issue in the litigation, and named defendant Lenovo Group Limited is their ultimate parent and holding company, and Patent Owner has identified Intel products as infringing.

Factor 6—other considerations—weighs against discretionary denial. None of the grounds asserted here were previously considered by either the Office or the district courts. *Cf. Comcast Cable Commc’ns, LLC v. Rovi Guides, Inc.*, IPR2019-00231, Paper 14 at 11 (PTAB May 20, 2019) (obviousness challenges not “previously considered by the Office or by any court” weigh in favor of not denying institution). Moreover, the ’703 patent is currently asserted in a district court case.

Institution of this IPR provides the opportunity for narrowing and simplifying the litigation for the district court.

Discretionary denial is also not warranted because this petition presents compelling evidence of unpatentability. As discussed above, the '703 patent admits that multi-user detectors were well known in the art. The '703 patent only purports to add enhancements to well-known multi-user detection techniques, such as joint amplitude estimation. These enhancement techniques, however, are clearly taught and rendered obvious by Brommer, Lilleberg, Hottinen, ElGamal, Frank, and Zha.

Accordingly, the Board should decline to exercise its discretion under *Fintiv* and institute trial.

B. § 325(d)

If the Samsung Petition is denied for procedural reasons, the same or substantially the same prior art arguments will not have been previously presented to the Office. The Examiner cited U.S. 6,956,893 ("Frank '893") in a Notice dated September 4, 2008, issued along with the Examiner's Notice of Allowance. However, the Examiner did not rely on Frank '893 as a ground of rejection, nor did the Examiner rely on Frank '893 in combination with other prior art, as this Petition relies on Frank in combination with Zha and Learned. Brommer, Hottinen, Lilleberg, Zha, ElGamal, and Learned were also not before the Examiner. Accordingly, the grounds here are different from the prior art of record that were before the Examiner

during prosecution of the '703 Patent.

X. MANDATORY NOTICES AND FEES

A. Real Party-In-Interest

Intel Corporation, Lenovo (United States) Inc., and Motorola Mobility LLC, are real parties-in-interest and, solely because it is named as a defendant in a co-pending district court case listed below, Lenovo Group Limited is also a real party-in-interest.

B. Related Matters

The '703 patent is the subject of civil actions, *Collision Communications, Inc. v. Samsung Electronics Co. Ltd. et al.*, 2-23-cv-00587 (E.D. Tex.), filed December 12, 2023 (pending), and *Collision Communications, Inc. v. Lenovo Group Ltd.*, 2-23-cv-00594 (E.D. Tex.), filed December 12, 2023 (pending). The '703 patent is also the subject of IPR2024-01500, filed September 30, 2024 (pending).

Petitioners are not aware of any other disclaimers, reexamination certificates, or IPR petitions addressing the '703 Patent.

C. Counsel and Service Information

Petitioners provide the following counsel and service information. Petitioners consent to electronic service to the email addresses listed in the table below. Pursuant to 37 C.F.R. § 42.10(b), Powers of Attorney accompany this Petition.

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D. Payment of Fees

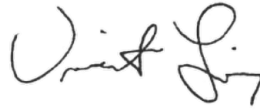
Petitioners state that the fee set forth in 37 C.F.R. § 42.15(a) for this Petition has been paid by electronic funds transfer, and Petitioners further authorize payment for any additional fees from the same account.

XI. CONCLUSION

For the reasons above, *inter partes* review is requested.

Date: December 12, 2024

Respectfully submitted,



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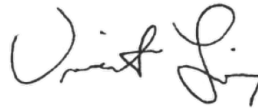
**CERTIFICATE OF COMPLIANCE WITH TYPE-VOLUME
LIMITATION, TYPEFACE REQUIREMENTS, AND TYPE STYLE
REQUIREMENTS**

1. This Petition complies with the type-volume limitation of 14,000 words, comprising 13,767 words, as counted using the Microsoft Word software that was used to prepare this paper, excluding the parts exempted by 37 C.F.R.

§ 42.24(a).

2. This Petition complies with the general format requirements of 37 C.F.R. § 42.6(a) and has been prepared using Microsoft® Word 2016 in 14-point Times New Roman.

Date: December 12, 2024



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Petition for *Inter Partes* Review
U.S. Patent No. 7,463,703

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CERTIFICATE OF SERVICE

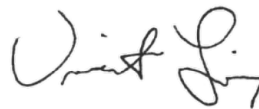
The undersigned hereby certifies that on December 12, 2024, true and correct copies of the foregoing document and supporting materials were served in its entirety on the Patent Owner at the following address of record as listed on PAIR via Priority Mail Express® or Express Mail:

Official Correspondence Address
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Courtesy copies were also sent via electronic mail to Patent Owner's counsel of record in the related district court proceeding

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