

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

v.

COLLISION COMMUNICATIONS, INC.,
Patent Owner.

Case No. IPR2025-00011

U.S. Patent No. 7,920,651

DECLARATION OF PAUL S. MIN, PH.D.
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 7,920,651

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Ex.	Description
1001	U.S. Patent No. 7,920,651 (“’651 Patent”)
1002	Prosecution History for 7,920,651
1003	Intentionally Omitted
1004	U.S. Patent No. 6,931,052 (“Fuller”)
1005	U.S. Patent No. 6,724,809 (“Reznik”)
1006	U.S. Patent Pub. No. 2003/0035469 (“Frank”)
1007	Intentionally Omitted
1008	Intentionally Omitted
1009	Intentionally Omitted
1010	Zha <i>et al.</i> , “Soft-Decision Successive Interference Cancellation CDMA Receiver with Amplitude Averaging and Robust to Timing Errors,” <i>in</i> Proc. IEEE Global Telecommunications Conference, 2001 (GLOBECOM ’01), vol. 2, 2001, pp. 743-747
1011	Sergio Verdu “Computational Complexity of Optimum Multiuser Detection,” <i>Algorithmica</i> (1989)
1012	Verdu, Sergio, “Multiuser Detection,” Cambridge University Press (1998)
1013	Shimon Moshavi, “Multi-User Detection for DS-CDMA Communications,” <i>in</i> IEEE Communications Magazine, Oct. 1996, pp. 124-136
1014	<i>Curriculum Vitae</i> of Dr. Paul Min

I. INTRODUCTION

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

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

3. I understand that this proceeding involves U.S. Patent No. 7,920,651 (the “’651 patent”), and I have been asked to consider the validity of certain claims of the ’651 patent based on certain prior art references. I have also been asked to consider the state of the art and prior art available as of April 14, 2003. Based on the prior art discussed in this declaration, it is my opinion that claims 1-4 and 6-8 of the ’651 patent are unpatentable for the reasons provided below.

II. QUALIFICATIONS AND BACKGROUND

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

III. LEGAL STANDARDS

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

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

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

A. Claim Construction

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

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

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

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

B. Anticipation Under 35 U.S.C. § 102

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

C. Obviousness Under 35 U.S.C. § 103

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

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

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

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

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

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

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

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

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

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

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

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

IV. THE '651 PATENT

A. Background Technology

33. I first begin with a summary of the technology involved with the '651 patent. In describing some of the basic concepts, I refer to a well-known text regarding wireless communications by Sergio Verdú: "Computational Complexity of Optimum Multiuser Detection," *Algorithmica* (1989) (Ex. 1011).

34. The '651 patent relates to multi-user detection, or "MUD." MUD techniques have been known for decades, and documented since at least the 1980s. Generally speaking, a MUD system allows users to transmit information over a shared communication path or channel. The users' information is transmitted as interfering signals over the shared communication path or channel. Interfering signals are signals that suffer from interference from another signal that overlaps in

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

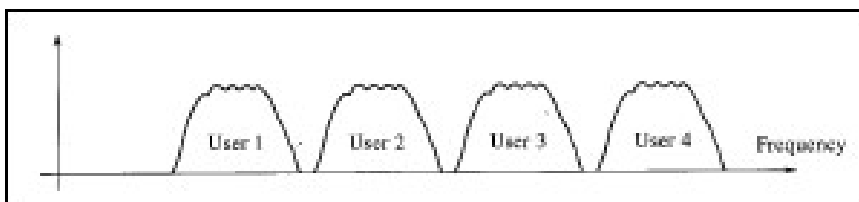
35. MUD is described by Sergio Verdu in "Computational Complexity of Optimum Multiuser Detection," *Algorithmica* (1989) (Ex. 1011). In 1989, MUD was well known as detecting signals for each user in a multi-user system. For example, one implementation of MUD was described as "[t]he optimum multiuser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

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

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

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

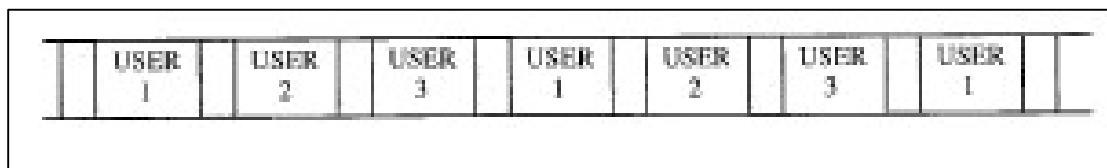
38. Another system pioneered by Qualcomm in the 1990s was Frequency Division Multiplexing or Frequency Division Multiple Access (“FDMA”). In FDMA systems, a different carrier frequency is assigned to each user in a network with a shared communication channel so that the resulting signals and spectra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



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

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

This is shown below:



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

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

multi-user detectors and subtractive interference cancellation detectors. Ex. 1013 at 126. Subtractive interference cancellation is particularly relevant to the '651 patent and the prior art discussed in this Declaration.

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

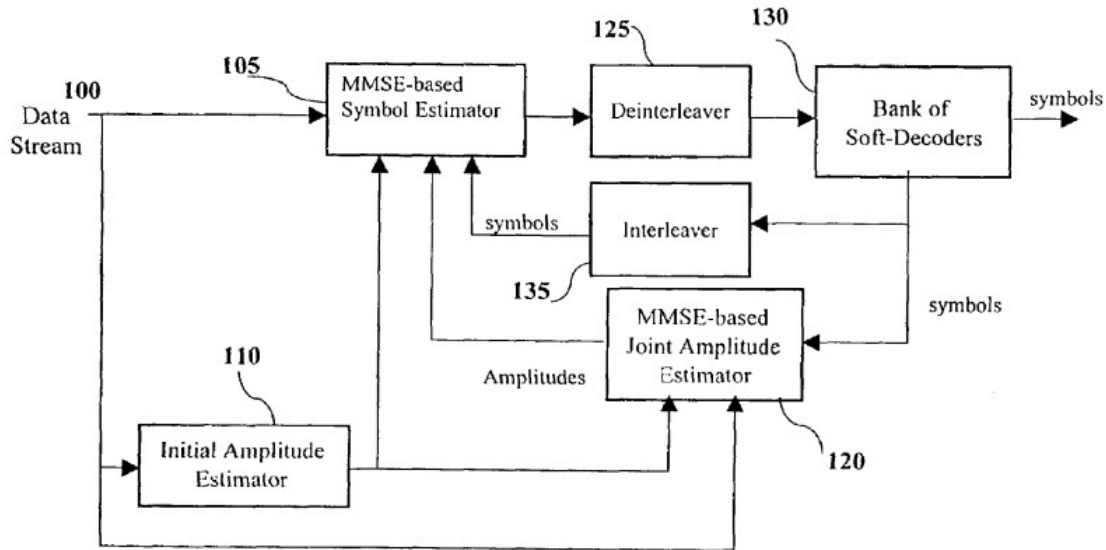
B. Overview of the '651 patent

44. The '651 patent is directed to "co-channel communications" and "increasing capacity by allowing interfering channels"—*i.e.*, multi-user detection. Ex. 1001, 1:29-32. The patent also indicates that it is related to several applications directed to multi-user detection systems. *Id.*, 1:6-25.

45. The '651 patent does not purport to invent MUD. Rather, it explains the prior art "describe[s] ... multiple user systems" where communications "are processed by a multi-user detector." *Id.*, 5:12-15. The patent notes that "[t]here are

various multiuser detectors in the art.” *Id.*, 6:23-29. However, it identifies various disadvantages to existing multi-user detection schemes. For example, the ’651 patent states that some linear multi-user detectors “suffer[] from a significant disadvantage in that [they] require[] knowledge of all parameters to perform processing.” *Id.*, 6:29-38. “Optimal MUD based on the maximum likelihood sequence estimator” is criticized because it is “computationally complex” and “not possible to accomplish in a real-time environment.” *Id.*, 6:39-47. “There are several suboptimal multiuser detectors that are less computationally complex and known in the art,” but the ’651 patent claims they “fail[] or cases of overloaded multiple access systems,” *e.g.*, “where the number of users is doubled or tripled relative to the existing state of the art.” *Id.*, 6:58-7:9. In sum, the ’651 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.*, 8:20-30.

46. The ’651 patent claims to invent a multi-user detection system that “provid[es] high quality real-time processing for multiple access systems, including overloaded situation.” Ex. 1001, 11:34-38. Figure 2 shows a “block diagram perspective ... for one embodiment of the invention.” *Id.*, 11:19-21.



47. In Figure 2, Data Stream 100 is communicated to MMSE-based Symbol Estimator 105. “[O]ther forms of symbol estimators ... are within the scope of the invention.” Ex. 1001, 14:61-15:2. The ’651 patent suggests some known MUD techniques for the symbol estimator, including “linear detectors, ... maximum likelihood; decorrelating decision-feedback detector; ... successive interference cancellation (SIC), [and] parallel interference cancellation (PIC) or multi-stage detector.” *Id.*, 15:56-67.

48. The received signal is also passed to an initial amplitude estimator and a joint amplitude estimator. *Id.*, 15:25-28. 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.*, 15:45-49.

49. Symbol estimates are provided to “a bank of single user decoders,” which output “symbol estimates and their respective likelihoods.” *Id.*, 16:1-4, 16:16-19. The estimates are iteratively “fed back around” to the symbol estimator and the joint amplitude estimator. *Id.*, 16:19-22. In each each iteration, “[t]he new symbol likelihoods from the decoders 130 are used to update previous amplitude estimates in the joint amplitude estimator 120.” *Id.*, 16:38-40. The symbol estimator “re-estimates the symbols based on prior information on the symbols and the updated parameter estimates.” *Id.*, 16:42-47. 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.*, 16:48-50.

50. Figure 5 shows “one embodiment of a hardware implementation ... that parallels the joint estimation based on M observation intervals.” *Id.*, 20:62-66.

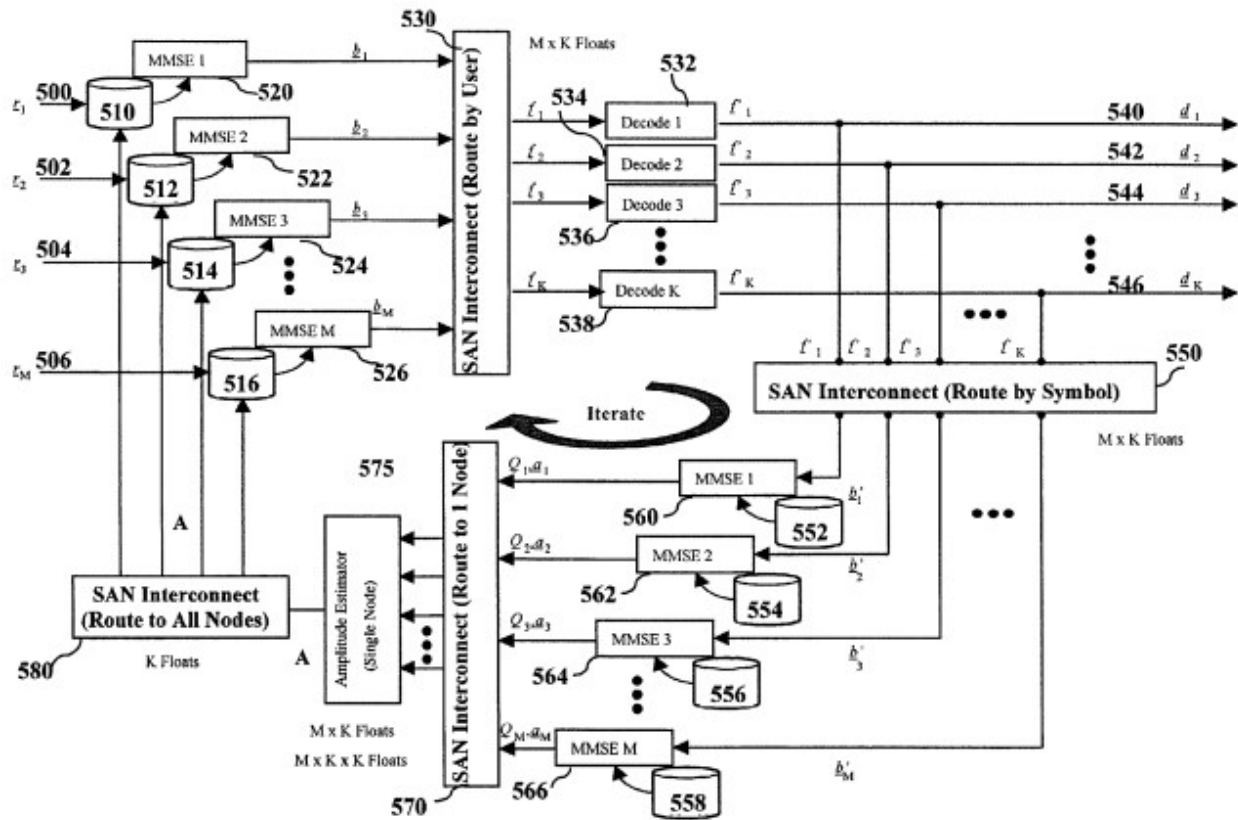


Figure 5

51. In Figure 5, “[t]he data stream ... is partitioned into M observation intervals.” *Id.*, 20:66-21:3. Each observation interval is an interval based on time, frequency, or code. *Id.*, 18:65-19:1. A “bank of ... processors” is used for “filter implementation for amplitude estimation, illustrated by processing modules 560, 562, 564, 566.” *Id.*, 22:17-24. Each processing module “computes an amplitude update vector,” which “is passed to a central node that implements the functionality of [an] Amplitude Estimator [575].” *Id.*, 22:32-39. The amplitude estimator updates “the amplitude estimate ... by weighting the sum of all amplitude updating vectors.”

Id., 20:11-18. Updated amplitude estimates are then used to “perform the symbol estimation processing ... on the next iteration using the new amplitude estimates.”

Id., 22:48-64. The process is repeated iteratively “until estimates of the bit error rate metric achieves a certain level or until a fixed number of iterations have been executed.” *Id.*, 22:64-47.

C. Prosecution History of the '651 patent

52. I have reviewed the prosecution history of the application that led to the '651 patent. Ex. 1002. I have provided a summary below of the prosecution history.

53. The application that led to the '651 patent was filed on June 25, 2009, and claimed priority back to a provisional application filed on April 14, 2003. Based on my review, there were no substantive rejections or amendments before the claims were issued. *See generally* Ex. 1002.

D. Person of Ordinary Skill in the Art

54. I am informed that patentability must be analyzed from the perspective of “one of ordinary skill in the art” in the same field as the '651 patent at the time of the invention. As previously discussed, the relevant time of invention is the patent’s priority date, which is no earlier than April 14, 2003. Moreover, I understand that whether or not a patent application provides “written description” support for patent claims must also be assessed from the perspective of a person of ordinary skill in the art.

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

56. A person of ordinary skill in the art pertinent to the '651 patent would have had at least a bachelor's in EE/CE/CS, physics, or equivalent, and two years of experience with cellular telecommunications, radio-access network architectures, protocols, and signal propagation in wireless networks. Additional education could substitute for professional experience and vice versa. A person of ordinary skill in the art would also be able to understand and apply the prior art discussed herein.

57. Although I surpass this definition of one of ordinary skill in the art now and at the priority date of the '651 patent, my analysis regarding the '651 patent has been based on the perspective of one ordinary skill in the art as of the priority date of the '651 patent.

58. I am also familiar with the knowledge of the person of ordinary skill in the art as of the priority date of the '651 patent. I am able to opine on how the person of ordinary skill in the art would have understood the disclosure and claims of the '651 patent, the disclosures of the prior art, the motivation to combine the prior art, and what combinations would have been obvious to one of ordinary skill in the art.

V. CLAIM CONSTRUCTION OF TERMS OF THE '651 PATENT

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

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

VI. OVERVIEW OF PRIOR ART

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

A. Fuller

62. U.S. Pat. No. 6,931,052 (“Fuller”) (Ex. 1004) was filed on November 16, 2001, published on May 22, 2003, and issued August 16, 2005. *See* Ex. 1004. I understand Fuller is prior art.

63. Fuller discloses methods and systems for “improved parallel interference cancellation” for “[a]n input signal composed of multiple user signals.” Ex. 1004, Abstract. In Fuller, an input signal composed of multiple user signals is processed over a time duration. An iterative process is used to estimate symbols for

each user, with the output of the last iteration being used as the final symbol decisions for each user signal.

64. For example, Figure 2 of Fuller shows parallel interference cancellation circuitry (“PIC”). Specifically, the PIC of Fig. 2 is referred to as “chip-level” PIC because the interference is cancelled at the chip-rate, with the received signal being “decimated” at the chip-rate so that the input signal 60 is a composite signal represented by chip-rate complex samples. Ex. 1004 at 4:37-41, 55-65. Fuller also discloses that “[f]or a specific time duration, or slot, the input signal is separated into M individual signals corresponding to each of the multiple users” as well as “demodulated to recover K symbols for each of the M individual signals.” Ex. 1004 at 4:11-23.

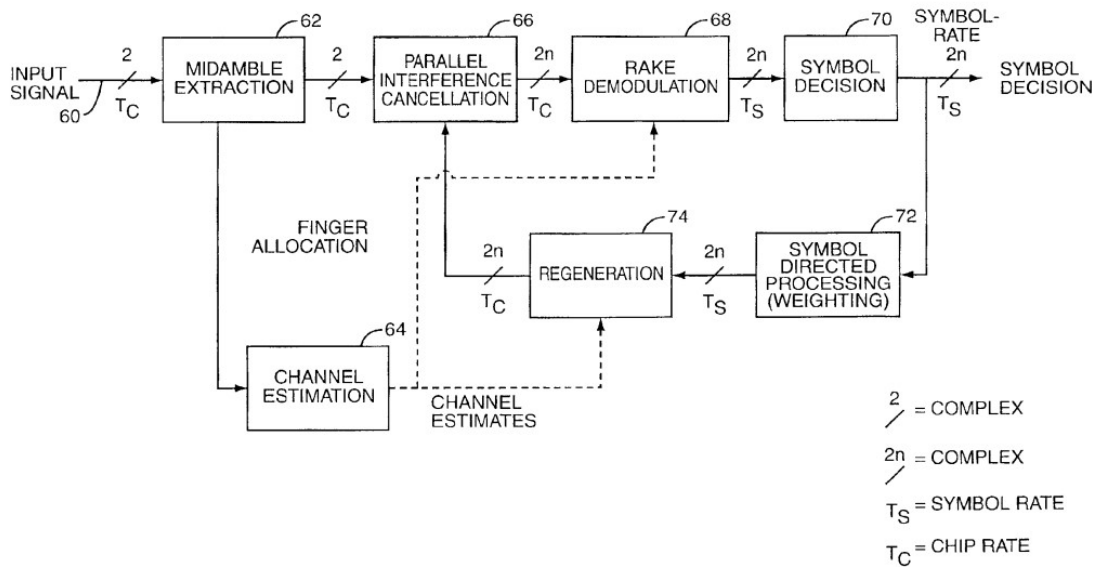


FIG. 2

65. In Figure 2, rake demodulation block 68 separates the input signal 60 into M individual signals corresponding to each user's signal. Ex. 1004, 5:9-18. Symbol-directed processing (weighting) block 72 weighs the symbol decision based on the consistency of previous estimates for the given symbol in earlier iterations, and provides individually weighted symbols. *Id.*, 5:31-39. Regeneration block 74 "recreates estimates of the individual signals from the weighted symbols for each of the estimated users and individually processes the modulated symbols based on the corresponding channel estimates." *Id.*, 5:41-45. The regenerated signals are used in the parallel interference cancellation block to "determine the individual signals for each user during subsequent iterations" by "subtract[ing] the regenerated signals

corresponding to all other individual signals from the composite input signal 60 for the given time slot.” *Id.*, 5:12-16.

B. Reznik

66. U.S. Patent No. 6,724,809 (“Reznik”) (Ex. 1005) was filed April 22, 2002, and issued on April 20, 2004. *See* Ex. 1005. I understand that Reznik is prior art.

67. Reznik discloses a parallel interference cancellation receiver that reduces impulse response interference using a model of the received signal similar to that used in block linear equalizers. Reznik discloses an interference computation processor feedback loop for correcting the output of a direct interference canceller, and further discloses observation intervals in the form of “chips.”

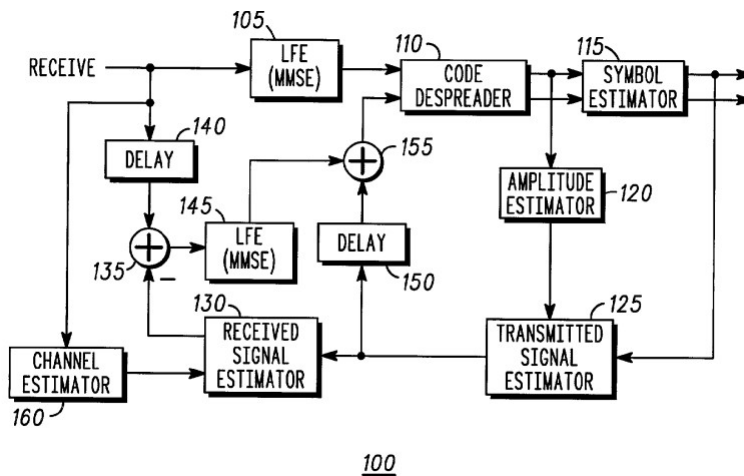
68. Reznik discloses that the data output from a communication receiver, as shown in Figure 3, “is coupled to a subchannel estimator which estimates the impulse response of each symbol transmitted in a respective sub channel.” Ex. 1005, 2:53-60. “W” is “the communication channel impulse response length in chips,” and “h(k)” is “the impulse response of the subchannel experienced by user k presented as a vector.” *Id.*, 3:14-15, 3:38-39. “The received data vector r is input to a plurality of channel estimators which independently estimate each user’s subchannel impulse response.” *Id.*, 6:54-62.

C. Frank

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

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

71. Frank discloses a system for interference cancellation, using both an amplitude estimator and a transmitted signal estimator as part of a feedback loop. Frank’s system is illustrated in connection with Fig. 1, which shows a receiver with interference cancellation using both an amplitude estimator which provides amplitude estimates for each channel, and transmitted signal estimator, which is used to regenerate the user signals to perform interference cancellation.



D. Zha

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

73. It is my opinion that Zha was publicly available by no 2001, and no later than August 2002. I am familiar with the IEEE’s publication practices, having served in multiple positions in the Saint Louis Section of the IEEE and on multiple IEEE committees, having served as a reviewer for multiple IEEE journals and publications, having participated in many IEEE conferences, and having published in many IEEE journals. The IEEE is a well-known and very reputable publisher of scientific and technical articles. The copyright dates indicated on the face of an IEEE-published paper is a strongly reliable indicator of its publication date and public availability. In this case, Zha indicates on its face that it was published in 2001.

74. I also note that Zha is listed on the IEEE Xplore website at <https://ieeexplore.ieee.org/document/965517>, with a date of publication on IEEE Xplore of August 6, 2002. A POSITA would consider the IEEE Xplore website as

a highly reliable indicator of the publication date of a paper. In my opinion, Zha is also a complete, true, and correct copy, since it is identical to the copy available on IEEE Xplore. Based on my review, Zha is complete and has no visible alterations. A POSITA would expect an IEEE-published paper to appear in the IEEE Xplore database. Zha also has all the hallmarks of an authentic copy of an IEEE paper, including the IEEE markings at the bottom of the first page, a stylized title, author information (including affiliations), and the organization of the paper.

75. 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.

76. Zha proposes an improved multiuser detector that incorporates amplitude averaging. *Id.*, 743. The detector has “multiple interference cancellation stages.” *Id.*, 744. In each stage after the first, each “user’s received signal is estimated by subtracting other users’ regenerated signals from the [combined] received signal”; the “averaged amplitude estimate” is then obtained “by averaging

the instantaneous estimate of” a particular user’s “amplitudes over a block of M bits”; and symbol estimates are then estimated and “normalized with respect to the averaged amplitude” to determine a “data bit decision.” *Id.* The data bit decision uses a “soft bit decision rule.” *Id.* The algorithm “is terminated after a desired number of interference cancellation stages.” *Id.*

VII. SUMMARY OF OPINIONS ON UNPATENTABILITY

77. In the analysis that follows, I identify the following combinations of prior art that, in my opinion, anticipate and/or render obvious the ’651 patent claims:

Ground	Basis	Reference(s)	Claims
1	§103	Fuller, Reznik	1-4, 6-8
2	§103	Frank, Zha	1-4, 6-8

A. Ground 1: Claims 1-4 and 6-8 are Rendered Obvious by Fuller in View of Reznik

78. I provide a summary of this ground as follows. Fuller discloses a parallel interference cancellation receiver that receives a data signal comprising multiple individual user signals and iteratively performs joint amplitude estimation. The joint amplitude estimation function uses a plurality of processors processing multiple code-based and time-based observation intervals in parallel to demodulate, filter, and regenerate the individual user signals, and generate updated signal estimates. Reznik also discloses parallel interference cancellation, and discloses additional filtering steps and conditions for determining when to complete the

iterative process and generate final symbol estimates. In my opinion, it would have been obvious to a POSITA to apply Reznik's teachings to Fuller, as I explain below.

1. Motivation to Combine and Reasonable Expectation of Success

79. In my opinion, and as I explain below, a POSITA would have been motivated to apply Reznik's teachings relating to interference cancellation to Fuller's parallel interference cancellation system, including Reznik's teachings relating to the use of matched filters to generate amplitude estimates and logic for determining when to complete iterative processing of interference cancellation.

80. Multi-user detection, and parallel interference cancellation specifically, was well known before the '651 patent. Ex. 1013 at 131. In my opinion, a POSITA would have recognized conventional aspects of parallel interference cancellation described in Reznik as known techniques, and would have found it obvious to apply those known techniques to a known method that was ready for improvement, such as Fuller's improved parallel interference cancellation system, to yield predictable results. For example, a POSITA would have recognized that Reznik's teaching of iterating for a fixed number of iterations or until a desired level of signal correction is achieved are two conventional and commonly used alternatives for iterative interference cancellation, and could readily be applied to Fuller's iterative solution. In my opinion, a POSITA would have had a reasonable expectation of success in

making such modifications because they merely entail implementing one prior art solution with well-known techniques from prior art in the same field.

81. In my opinion, a POSITA would have also understood that both Fuller and Reznik disclose specific improvements to parallel interference cancellation in the context of CDMA communications systems that address problems known in the art. For example, Fuller teaches that in conventional parallel interference cancellation, “each cancellation iteration involves an attempt to complete cancel out all MAI [multiple access interference].” Ex. 1004, 1:36-38. “However, if the MAI estimate for a particular user is based on an incorrect data decision, then the interference power contributed by that user is artificially increased when interference cancellation is performed.” *Id.*, 1:40-43. Fuller thus discloses a weighting technique to weight symbol estimates differently for performing interference cancellation, based on “the consistency of previous estimates of the given symbol.” *Id.*, 2:24-27. Reznik teaches that an “inherent problem with prior art PIC receivers resides in the received signal model that is used.” Ex. 1005, 7:42-46. Reznik discloses an improved “parallel interference cancellation receiver system and method” that “reduces impulse response interference using a model of the received signal similar to that used in block linear equalizers.” *Id.*, 8:2-5. In my opinion, a POSITA would have understood that Fuller and Reznik solve different known problems in the same type of CDMA-based parallel interference cancellation receiver, and would have

been motivated to look to Reznik to further improve Fuller's system. Reznik's use of a matched filter to determine individual amplitude estimates is part of its improved data estimation and interference cancellation technique, and would be one aspect of Reznik that a POSITA would be motivated to add to Fuller's system. *See id.*, 9:37-10:15.

82. In addition, both references reflect improvements over and contributions to the field of multi-user detection, a compact field of study related to code division multiplexing methods introduced in cellular standards in the 1990s. In standardized fields, such as cellular communications, it is common and natural to combine ideas from different references to achieve the best solution, as the resulting solution is widely implemented if the standard is adopted and successful. Accordingly, in my opinion, a POSITA would be motivated to combine the above-identified contributions, and variations thereof, to identify acceptable solutions taking into account cost, efficiency and complexity. These combinations would also have been a combination of prior art elements according to known methods and obvious to try given that there were a finite number of identified, predictable solutions in the prior art.

83. In my opinion, A POSITA would have reasonably expected this combination to succeed. Filtering and iterative interference cancellation had long been known in the field of multi-user detection and a POSITA would have been

familiar with these techniques as described by Reznik. Implementing Reznik's teachings into Fuller would have been well within the capabilities of a POSITA, especially because Fuller already discloses both matched filtering and the use of parameters associated with each interfering signal, such as phase, timing offset, received power, etc. In my opinion, a POSITA would therefore understand Reznik is compatible with Fuller.

84. Finally, it is my opinion that Fuller, Reznik, and the '651 patent are analogous art because all three are directed to the same field of multi-user detection and interference cancellation. *See* Ex. 1001, 1:29-32 ("The present invention relates to communications and more particularly to co-channel communications, and more particularly to increasing capacity by allowing interfering channels."), 19:46-49 ("Prior to application of the MMSE filter, interference cancellation is performed."), 25:16-30 (describing purported advantages of alleged invention in the context of CDMA systems); Ex. 1004, 1:7-11 ("The present invention relates to wireless communications, and in particular to enhancing parallel interference cancellation employed in code-division multiple access communication systems."); Ex. 1005, 1:14-17 ("[T]he invention relates to a parallel interference cancellation receiver system and method for the simultaneous reception of data from multiple users."), 8:16-18 ("[I]t is an object of the present invention to provide a system and method of receiving and decoding a plurality of signals over a CDMA interface.").

2. Claim 1

(a) [1pre]: “A joint amplitude estimator for a data stream from multiple users, comprising:”

85. In my opinion, Fuller renders the preamble obvious to the extent it is limiting.

86. Fuller discloses a “parallel interference cancellation (PIC) system” where “the input signal is composed of multiple (M) user signals separated by orthogonal codes.” Ex. 1004, 4:11-13; *see also id.*, 6:9-22 (example where “the input signal 60 is composed of four user signals”). Fuller’s input signal is thus a data stream from multiple users. Fuller’s “PIC detector circuitry” is illustrated in Figure 2. *Id.*, 4:37-39.

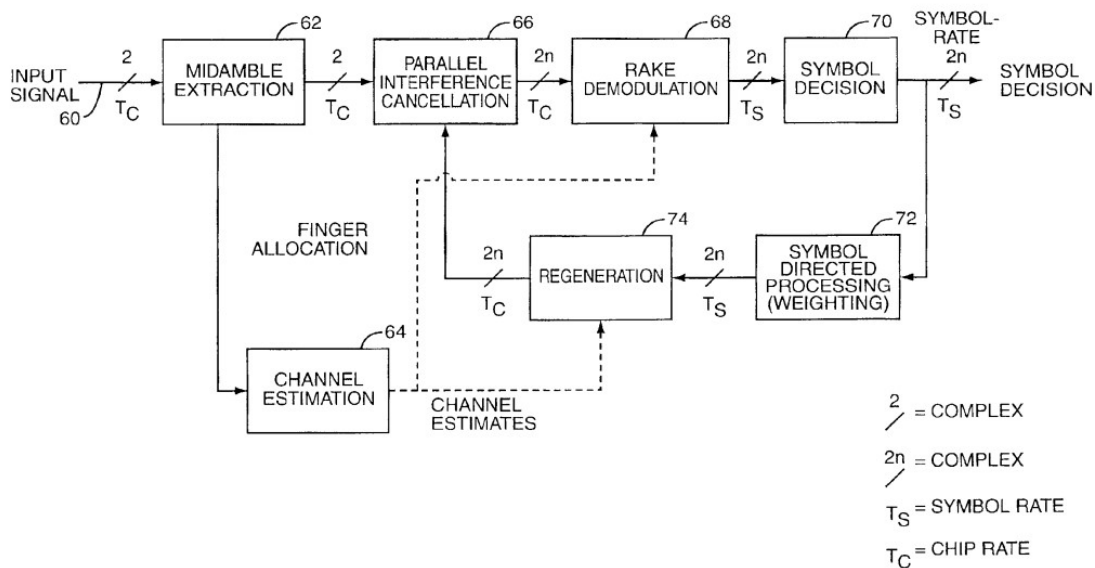


FIG. 2

87. As I discuss in more detail in the limitations below, Fuller's PIC system includes the claimed joint amplitude estimator.

88. Accordingly, Fuller discloses this element.

(b) [1a]: "a data stream from said multiple users divided into a plurality of observation intervals;"

89. In my opinion, Fuller discloses this element.

90. With respect to the element **"a data stream from said multiple users"**, Fuller discloses that the "input signal," which is at least part of the data stream, is "composed of multiple user signals." Ex. 1004, 2:20-21; *see also id.*, 4:58-61 ("[I]nput signal 60 is a composite signal represented by chip-rate complex samples."), 6:9-22 (describing operation in a "four (4) user system" where "the input signal 60 is composed of four user signals separated by orthogonal codes in a CDMA system").

91. With respect to the element **"divided into a plurality of observation intervals"**, Fuller discloses a "rake demodulator 68" that "separates the composite input signal 60 into M individual signals corresponding to the respective signals for each user"—each of which would be an observation interval. Ex. 1004, 5:9-11. In my opinion, a POSITA would have understood that in a CDMA system such as Fuller's, each user's signal corresponds to a different code, and the individual user

signals are thus observation intervals. This is consistent with the '651 patent, which defines as observation intervals “based on distinguishing attributes selected from at least one of the group consisting of: time, code, and frequency.” Ex. 1001, 10:16-18.

92. Fuller also discloses performing parallel interference calculation over multiple iterations. Ex. 1004, 2:32-34 (“The new individual signals are each demodulated and reprocessed for multiple iterations). Each iteration processes the individual user signals for “a specific time period, or slot,” which is also an observation interval according to the definition provided in the '651 patent. *Id.*, 6:14-31. “Throughout each iteration, subsequent slots of data can be processed in parallel.” *Id.*, 6:41-42. In my opinion, a POSITA would have understood that this means each slot corresponds to a time interval of the input signal and represents an observation interval of the data stream. Thus, the different “slots” are also a plurality of observation intervals.

93. Accordingly, Fuller discloses this element.

- (c) **[1b]: “a plurality of processing modules coupled to said observation intervals, wherein said processing modules calculates interference cancellation values for each of said users and computes a filter for each of said observation intervals, said filter being applied to said data within said observation interval to compute individual amplitude estimates; and”**

94. In my opinion, Fuller renders obvious this element in combination Reznik.

95. With respect to the element **“A plurality of processing modules coupled to said observation intervals”**, Figure 3 of Fuller shows that each of the individual user signals, which represent an observation interval based on a code, are processed separately and in parallel within the PIC system. Fuller states that Figure 3 “illustrates the logical flow of a four (4) user system taking four iterations to determine the estimated symbols for the respective signals associated with each user.” Ex. 1004, 6:9-11. After the input signal is divided into observation intervals for each user signal, each user signal is demodulated, weighted, regenerated, and subject to parallel interference cancellation. *Id.*, 6:14-31. Figure 3 shows that as the observation intervals corresponding to the user signals are processed in the system, there are “as many paths as users.” *Id.*, Fig. 3. In my opinion, a POSITA would have understood that each “path” is processed separately and in parallel by one of multiple processing modules. At a minimum, it would have been obvious to a POSITA to process each path using a different processing module, because it was well known that parallel processing using multiple processors may be used to increase the speed and throughput of a system.

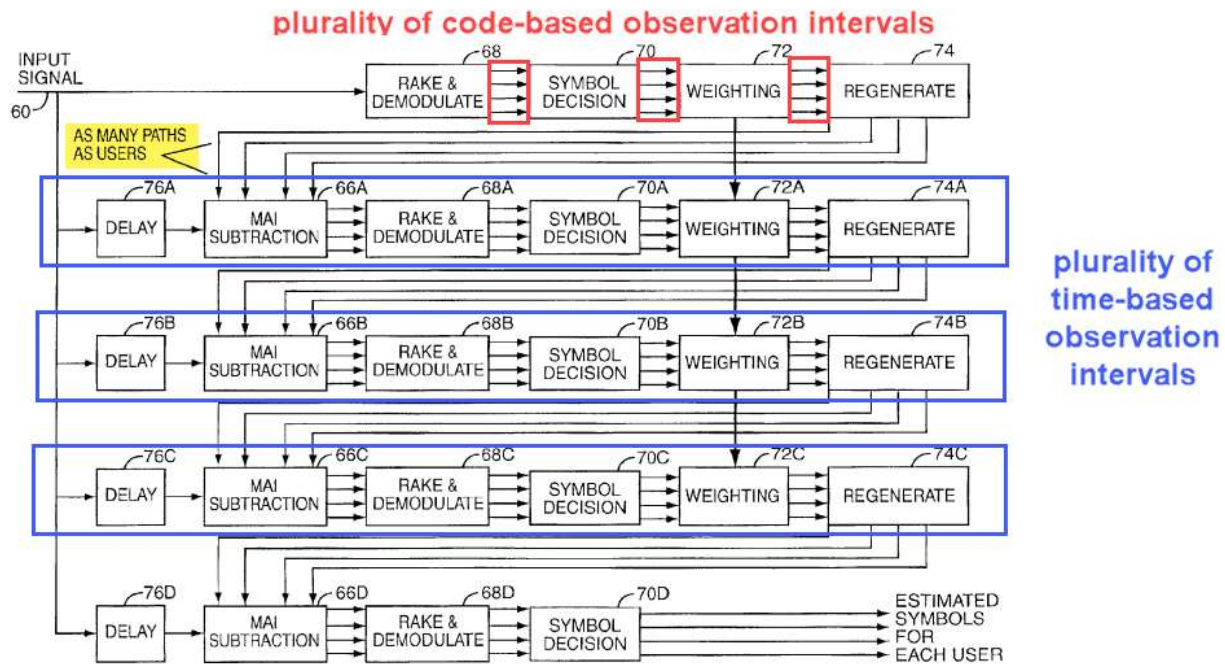


FIG. 3

96. In addition, as I discussed above for Limitation [1a], Fuller teaches dividing the input signal into multiple time slots that are processed in parallel. Ex. 1004, 6:41-42 (“Throughout each iteration, *subsequent slots of data* can be processed in parallel.”). As I explained above, each time slot is also an observation interval as defined in the ’651 patent. Fuller discloses that each of these time slots is processed in parallel across iterations of the PIC system, as shown in Figure 3. *Id.*; see also *id.*, claim 3 (“portions of the input signal over subsequent periods are processed in parallel with iterative processing of portions of the input signal over previous periods”).

97. With respect to the element **“wherein said processing modules calculates interference cancellation values for each of said users”**, Fuller discloses a “parallel interference cancellation” (PIC) function, represented by block 66 in Figure 2. Ex. 1004, 4:49-54. The PIC function “determine[s] the individual signals for each user” by performing a series of steps that includes “subtract[ing] the regenerated signals corresponding to all other individual signals from the composite input signal 60 for the given time slot.” *Id.*, 5:12-16. In my opinion, a POSITA would have understood that the regenerated signal for each user is used as an interference cancellation value for estimating the signals of other users; and the sum of every other user’s regenerated signal represents the interference cancellation value for a particular user. In other words, when performing interference cancellation for user k , the regenerated signals for every other user are summed and subtracted from the input signal for that time slot.

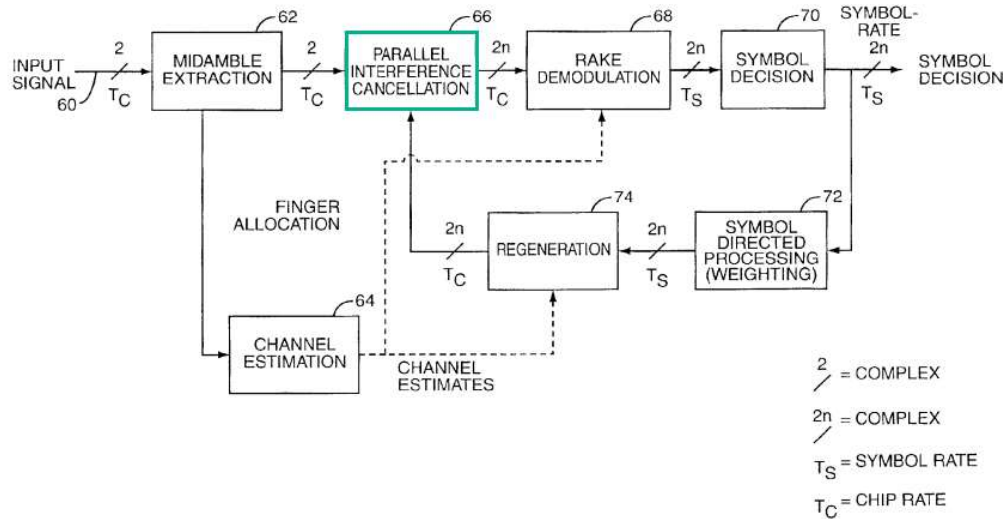


FIG. 2

98. The PIC function is also shown in Figure 3, identified by the “MAI subtraction” blocks 66A-D. *See* Ex. 1004, 6:25-29 (describing block 66A as a “PIC function”). The MAI subtraction block “form[s] an estimate for the individual signal” for each user in each iteration. *Id.*, 6:23-41. As I explained above, in my opinion, a POSITA would have understood that within each iteration, each individual user signal, which is an observation interval based on a code, is processed in parallel because each user signal follows a separate parallel path through the system. Fuller also expressly teaches that for each observation interval corresponding to a time slot, parallel interference cancellation for each user is “processed in parallel.” *Id.*, 6:41-42.

99. With respect to the element **“wherein said processing modules ... computes a filter for each of said observation intervals, said filter being applied**

to said data within said observation interval to compute individual amplitude estimates”, Fuller discloses a rake demodulator that “separates the composite input signal 60 into M individual signals corresponding to the respective signals for each user.” Ex. 1004, 5:9-12. In my opinion, a POSITA would have understood that each of these individual signals in a CDMA system is an observation interval based on a code. A POSITA would have also understood that each signal has a corresponding amplitude, because a signal is defined in part based on its amplitude. The M individual signals would thus have a plurality of individual amplitude estimates, one for each signal.

100. Fuller also teaches that the rake demodulation function may be “provided in hardware, software, or a combination thereof.” Ex. 1004, 4:49-54. For a software implementation, a processor would be needed to execute the software. As illustrated in Figure 3, the rake demodulator produces a separate, parallel output for each user (*i.e.*, four outputs for four users in the example in Figure 3). In my opinion, a POSITA would have understood that a separate processing module is used to process the rake demodulation of each user’s signal. At a minimum, it would have been obvious to a POSITA to process each individual user signal using a different processing module, because it was well known that parallel processing using multiple processors may be used to increase the speed and throughput of a system.

101. A POSITA would have understood that Fuller's rake demodulator is or includes a filter. However, it would have also been obvious to a POSITA in view of Reznik to use a plurality of matched filters (one for each user) instead of or in addition to Fuller's rake demodulator to generate the M individual signals for each code/user, and their corresponding amplitude estimates. Reznik teaches that "demodulating [a] desired subchannel" (corresponding to a particular user) may be performed using "matched filter and RAKE receivers." Ex. 1005, 2:17-18. Reznik further explains that "[t]o obtain user data $d^{(k)}$ for a specific user from the combined user data r , the user data r must be filtered using a matched-filter 35 or the like." *Id.*, 9:47-49. The output of each matched filters is "a first rough estimate of the corresponding symbol in the transmitted data vector d ." *Id.*, 9:62-65. In my opinion, it would have been obvious to a POSITA based on these disclosures to use a plurality of matched filters to generate Fuller's individual amplitude estimates from the composite input signal. For a software implementation (as contemplated by Fuller), a POSITA would have understood that the processors (discussed above) would be used to compute and apply the matched filters.

102. Fuller also discloses a "signal regeneration" function that satisfies this limitation. *See* Ex. 1004, 5:41-63. The regeneration function "recreates estimates of the individual signals ... for each of the estimated users and individually processes the modulated symbols based on the corresponding channel estimates." *Id.*, 5:41-

44. In my opinion, a POSITA would have understood that the channel estimates include amplitude estimates, because channel estimates normally include an estimate of the channel gain, which corresponds to the signal amplitude. A POSITA would have also understood that the estimated individual signals include at least estimated amplitudes because, as I note above, a signal is defined in part by its amplitude. As shown in Figure 3, the signal regeneration function is applied within each time slot (corresponding to an observation interval) to separately produce estimates of the individual signals and their corresponding amplitudes for each user. *Id.*, Fig. 3; *see also id.*, 6:23-31. Fuller also teaches that the regeneration function includes, “for each user,” “filtering the spread and scrambled signal with the user’s channel estimate.” *Id.*, 5:44-45, 5:51-52. As with the rake demodulator, Fuller’s regeneration function may be implemented in software. *Id.*, 4:49-54. As I explain above, a POSITA would have understood that processing of each user’s signal (including regeneration and filtering) would be performed in parallel using separate processing modules; and, at a minimum, it would have been obvious to a POSITA to process the signals in parallel using separate processing modules to increase speed and efficiency. In addition, since each signal is filtered using “the user’s channel estimate” (Ex. 1004, 5:51-52), a POSITA would have understood that a filter must be separately computed for each user, using that user’s channel estimate.

103. As I explain above in Section VII.A.1, in my opinion, a POSITA would have been motivated to combine Fuller and Reznik, and would have reasonably expected the combination to succeed.

104. Accordingly, Fuller in combination with Reznik renders obvious this element.

- (d) [1c]: “an amplitude estimation unit which processes said individual amplitude estimates and calculates new amplitude estimates, wherein said new amplitude estimates are iteratively passed back to said processing modules either a maximum number of iterations or a desired bit error rate have been reached.”

105. In my opinion, Fuller render obvious this limitation.

106. With respect to the element “**an amplitude estimation unit which processes said individual amplitude estimates and calculates new amplitude estimates**”, Fuller discloses a “symbol-directed processing” function that “provides a weighting for each regenerated chip based on the consistency of previous estimates.” Ex. 1004, 9:31-40. For each time slot, which corresponds to an observation interval, the symbol-directed processing function receives “estimates of the individual signals from the estimated symbols for each of the estimated users,” each of which includes an individual amplitude estimate, as I explain above. This is illustrated in Figure 10. *Id.*, 9:10-14, 9:31-33.

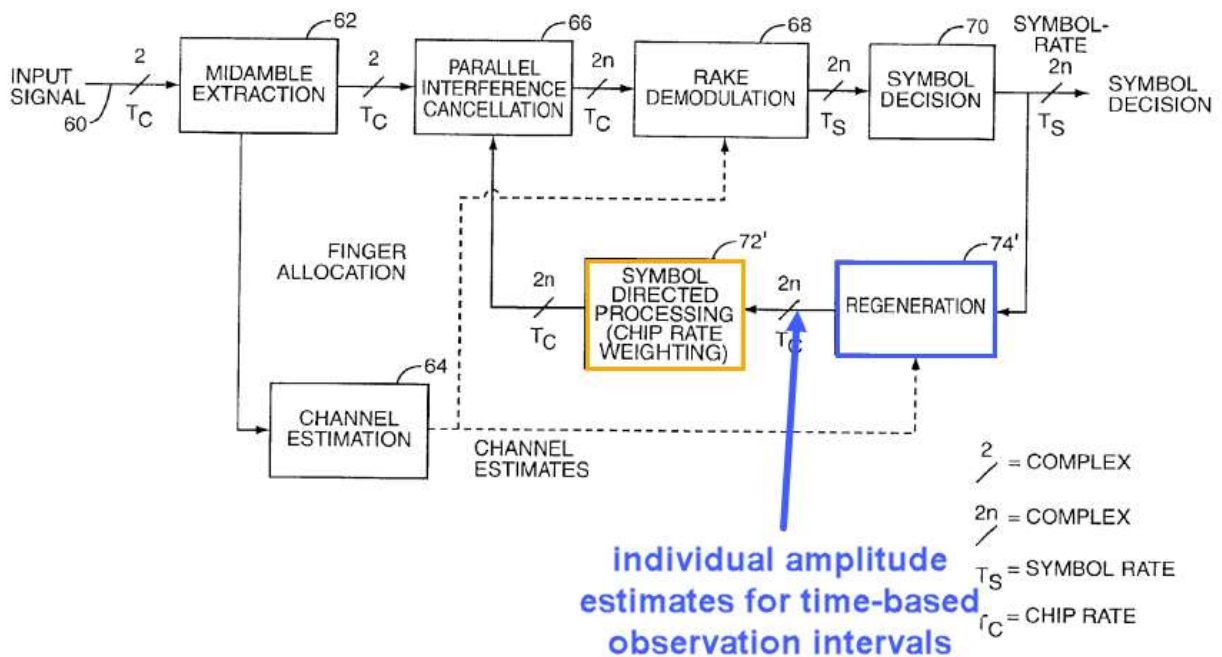


FIG. 10

107. Although Figure 10 and the quotes above describe an “alternative embodiment” that is slightly different from the embodiments of Figures 2 and 3, the difference between the two embodiments is in the sequencing of the weighting and regeneration functions are reversed. Ex. 1004, 8:28-30. In Figures 2 and 3, weighting is performed before regeneration; in Figure 10, weighting is performed after regeneration. In my opinion, a POSITA would have understood that the other functions in Fuller’s system—including the parallel interference cancellation function, the rake demodulation function, and the regeneration function—are otherwise performed in substantially the same way in both the embodiment of Figures 2-3 and the embodiment of Figure 10. For the same reasons Fuller’s

embodiments in Figures 2 and 3 disclose the limitations of claim 1, as I discuss above, Fuller's embodiment in Figure 10 would also disclose those limitations.

108. Returning to Figure 10, after regeneration, the symbol-directed processing function "provides a weighting for each regenerated chip based on the consistency of previous estimates for the given chip from earlier iterations." *Id.*, 9:35-40. "In effect, the symbol-directed processing 72' provides regenerated signals for each user having individually weighted symbols based on the consistency of the symbols over multiple iterations." *Id.*, 9:40-43. In my opinion, a POSITA would have understood that the weighted signal estimates include new (weighted) amplitude estimates, because they apply a weight to each individual regenerated signal (which has a corresponding individual amplitude).

109. Alternatively, when considering Fuller's observation intervals based on codes, and as I discuss above for Limitation [1b], Fuller's rake modulation function (as modified in view of Reznik) "separates the composite input signal 60 into M individual signals corresponding to the respective signals for each user," each of which is an observation interval based on a code. Ex. 1004, 8:55-58. As I discuss above, a POSITA would have understood that each signal has a corresponding amplitude estimate. The symbol decision function, regeneration function, and symbol directed processing function collectively comprise an amplitude estimation unit for these individual signals, as illustrated in Figure 10. That is because the

elements perform the following sequence of steps to calculate new amplitude estimates based on the individual amplitude estimates: (1) the symbol decision function determines symbol estimates for each user; (2) the regeneration function “recreates estimates of the individual signals from the estimated symbols for each of the estimated users”; and (3) the symbol-directed processing function “provides a weighting for each regenerated chip.” Ex. 1004, 9:4-43. The weighted, regenerated signals include new amplitude estimates, and are based on the individual amplitudes originally determined by the rake demodulation function.

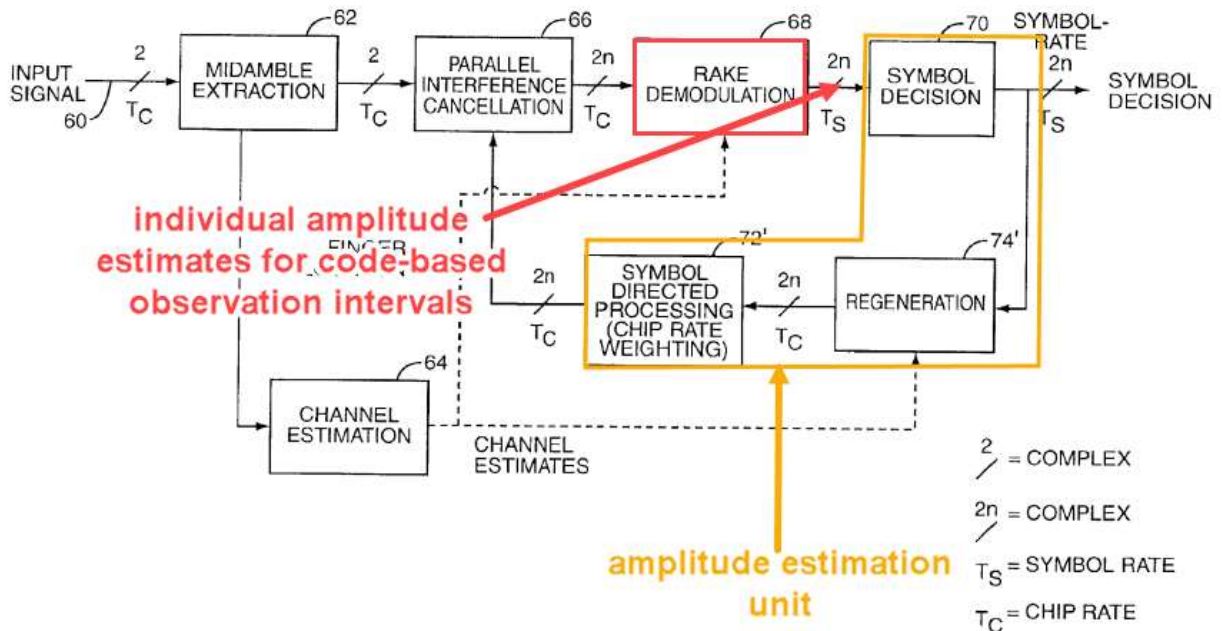


FIG. 10

110. With respect to the element **“wherein said new amplitude estimates are iteratively passed back to said processing modules”**, Figure 3 of Fuller shows that the new amplitude estimates output by the symbol-directed processing function

are passed back to the parallel interference cancellation function that calculates interference cancellation values, the rake demodulation function, and/or the regeneration function that perform filtering to compute individual amplitude estimates, all of which may be implemented in software on the processing modules, as I discuss above. Ex. 1004, 8:62-64 (“The weighted signals for each user are fed back via the regeneration and symbol-directed processing functions 74’, 72’), 9:37-38 (“The resulting signal is then provided to the PIC function 66 for cancellation.”).

111. With respect to the element **“either a maximum number of iterations or a desired bit error rate have been reached”**, Fuller discloses that parallel interference cancellation involves an iterative process. Ex. 1004, Abstract (“The new individual signals are each demodulated and reprocessed for multiple iterations.”), 3:1-3 (Fig. 3 is a logical illustration of a cancellation process for four users over four iterations.”). The process may be repeated “for as many iterations as desired.” *Id.*, 4:24-26. In my opinion, a POSITA would have understood that this entails iterating a fixed number of times, until the “desired” maximum number of iterations has been reached.

112. Alternatively, Reznik discloses parallel interference cancellation where the “iterative interference subtraction process may be repeated m times depending upon the degree of desired signal correction.” Ex. 1005, 10:16-29. “After m iterations, the interferers are removed” and the system outputs the data “for final

output symbol generation.” *Id.* In my opinion, a POSITA would understand from this disclosure that (1) a maximum number of iterations (m) is used, and (2) the number of iterations are used to achieve a desired signal correction or error rate. In wireless communications, error rate is typically measured as bit error rate or word error rate, and it would have been obvious to a POSITA to use either metric for measuring the error rate.

113. As I explain above in Section VII.A.1, in my opinion, a POSITA would have been motivated to combine Fuller and Reznik, and would have reasonably expected the combination to succeed.

114. Accordingly, in my opinion, Fuller in view of Reznik renders obvious this element.

3. Claim 2: “The joint amplitude estimator 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.”

115. In my opinion, Fuller in combination with Reznik renders obvious this claim.

116. As I explain above in connection with Limitation [1c], Fuller discloses iterating until a predetermined, fixed number of iterations is reached. Ex. 1004, Abstract (“The new individual signals are each demodulated and reprocessed for multiple iterations.”), 3:1-3, 4:24-26.

117. Alternatively, a fixed number of iterations for achieving a bit error rate metric level would have been obvious in view of Reznik. As I explain above for Limitation [1c], Reznik discloses iterating for a fixed number of iterations, “m,” in order to achieve a desired signal correction, which could be measured as either bit error rate or word error rate. Ex. 1005, 10:16-29.

118. As I explain above in Section VII.A.1, in my opinion, a POSITA would have been motivated to combine Fuller and Reznik, and would have reasonably expected the combination to succeed.

119. Accordingly, in my opinion, Fuller in view of Reznik renders obvious this element.

4. Claim 3: “The joint amplitude estimator according to claim 1, wherein said amplitude estimation unit sums and weighs said individual estimates.”

120. In my opinion, Fuller discloses this claim.

121. Fuller discloses that its symbol-directed processing function, which is used to calculate new amplitude estimates, as discussed in Limitation [1c], “provides a weighting for each regenerated chip based on the consistency of previous estimates for the given chip from earlier iterations.” Ex. 1004, 9:35-40. “In effect, the symbol-directed processing 72’ provides regenerated signals for each user having individually weighted symbols based on the consistency of the symbols over

multiple iterations.” *Id.*, 9:40-43. As I explain above for Limitation [1c], this weighting is performed on the individual amplitude estimates for each user’s signal.

122. Fuller also discloses that the weighting factors used to weight each estimate may be computed in a number of different ways based on prior symbol estimates, which are based on and derived from the user’s signals and their corresponding individual amplitude estimates. Ex. 1004, 6:54-7:12, Figs. 5-7. For example, the weighting algorithm shown in Figure 6 involves summing prior symbol estimates and their corresponding individual amplitude estimates to generate a weight for the corresponding user. *See* Ex. 1004, Fig. 6.

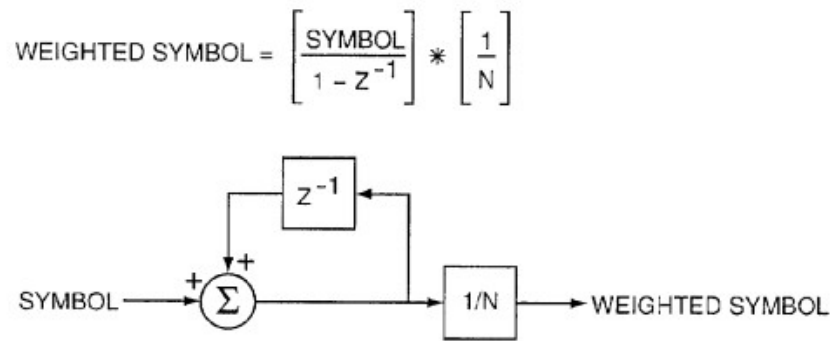


FIG. 6

123. Accordingly, Fuller discloses this claim.

5. **Claim 4: “The joint amplitude estimator according to claim 1, wherein said observation intervals are based on distinguishing attributes selected from at least one of the group consisting of time, code, and frequency.”**

124. *See* Limitation [1a].

6. **Claim 6**

- (a) **[6pre]: “A method for processing amplitude estimates for a multiuser data stream divided into a plurality of observation intervals, comprising:”**

125. *See* Limitations [1pre], [1a].

- (b) **[6a]: “computing a filter for each said observation interval of said data stream”**

126. *See* Limitation [1b].

- (c) **[6b]: “applying interference cancellation to said data stream for each said observation interval”**

127. *See* Limitation [1b].

- (d) **[6c]: “applying said filter to said data stream for each said observation interval from said interference cancellation to produce individual amplitude estimates for each said observation interval”**

128. *See* Limitation [1b].

129. In addition, Fuller shows in Figure 3, that the filter is applied to the data stream from the interference cancellation. Specifically, as I explain above in for Limitation 1[b], Fuller’s rake demodulation function (as modified in view of Reznik) applies a filter to each user’s signal, which is an observation interval based on a code. This is illustrated in red in the annotated figure below. For each time slot, which is also an observation interval, filtering is also performed at Fuller’s regenerate function, which is illustrated in blue in the figure below. Figure 3 shows that both functions operate on the data stream from the interference cancellation function (the MAI subtraction function in Figure 3).

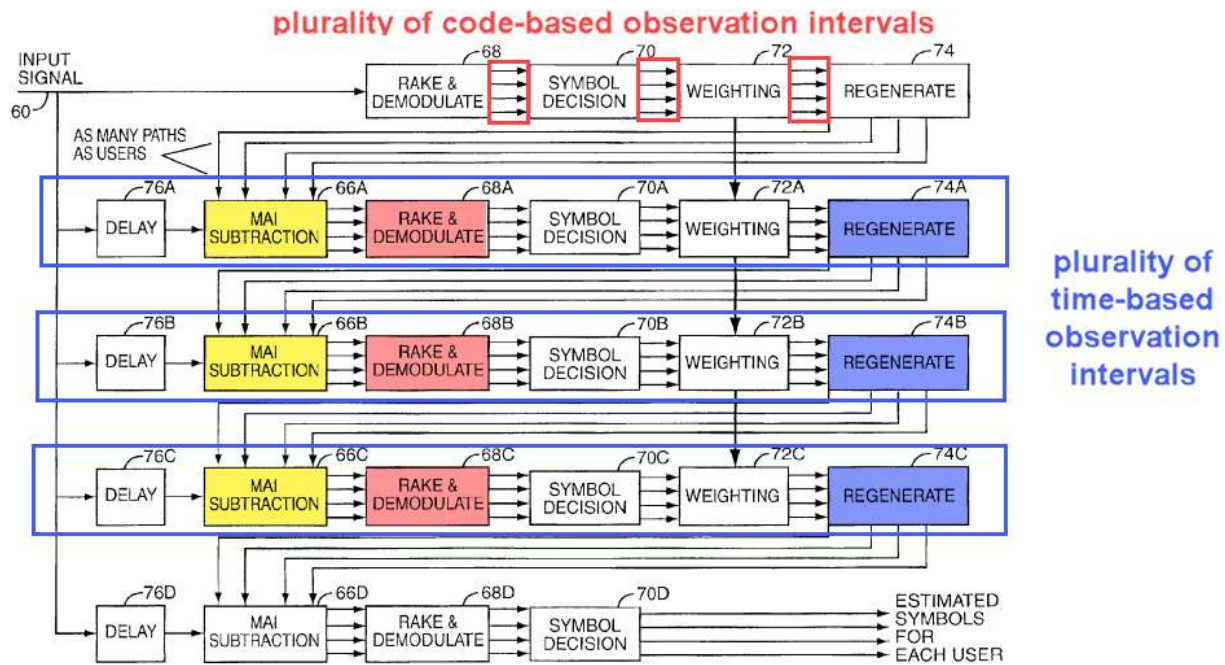


FIG. 3

130. Accordingly, Fuller discloses this limitation.

(e) [6d]: “computing new amplitude estimates using said individual amplitude estimates; and”

131. See Limitation [1c].

(f) [6e]: “passing said new amplitude estimates back to said filter for iterative processing until either a maximum number of iterations or a desired bit error rate have been reached.”

132. See Limitation [1c].

7. **Claim 7:** “The method according to claim 6, wherein said computing further comprises summing said individual amplitude estimates and weighing.”

See Claim 3.

8. **Claim 8: “The method according to claim 6, wherein said final condition is selected from at least from the group consisting of bit error rate metric level and fixed number of iterations.”**

See Claim 2.

B. Ground 2: Claims 1-4 and 6-8 are Rendered Obvious by Frank in view of Zha

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

1. Motivation to Combine and Reasonable Expectation of Success

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

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

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

136. In my opinion, a POSITA would have reasonably expected this combination to succeed. Successive interference cancellation was well known in the field prior to the ’651 patent, and would have been familiar to a POSITA. Zha discloses specific improvements to these well-known techniques, which a POSITA would have been capable of applying to Frank’s receiver. Implementing Zha’s improvements in Frank’s system would have been well within the capabilities of a POSITA.

137. Finally, in my opinion, Frank, Zha, and the '651 patent are analogous art because all three are directed to the same field of multi-user detection, that is, processing a data stream from multiple users using joint signal detection techniques. Ex. 1006, [0001] (“The present invention relates, in general, to receivers for code division multiple access (CDMA) communication systems”), [0005] (CDMA ... has multiple users plus noise in the channel.”); Ex. 1010, 743 (“Successive interference cancellation (SIC) is a low-complexity multiuser detection method for DS/CDMA systems. ... We propose a new soft-decision rule to be used with amplitude averaging.”); Ex. 1001, 1:29-32 (“The present invention relates to communications and more particularly to co-channel communications, and more particularly to increasing capacity by allowing interfering channels.”).

2. Claim 1

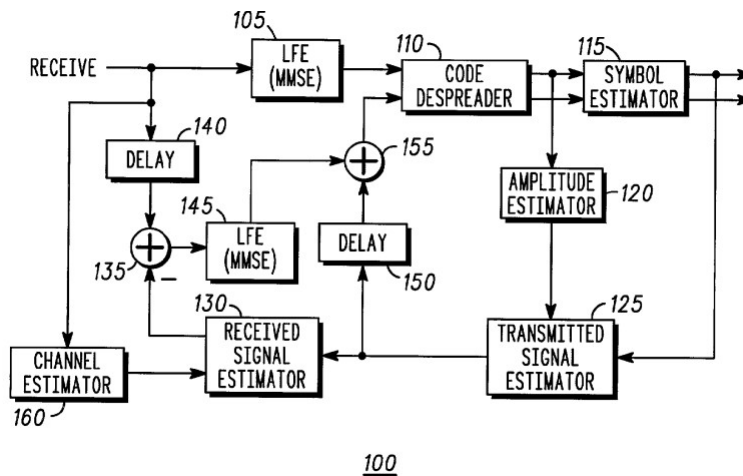
(a) [1pre]: “A joint amplitude estimator for a data stream from multiple users, comprising:

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

139. Frank discloses “receivers for code division multiple access (CDMA) communication systems.” Ex. 1006, [0001]. In my opinion, a POSITA would have known that CDMA communication systems include data streams from multiple users. Frank’s receivers also receive and process a digital data stream from multiple users, such as a signal in a CDMA communication system. Ex. 1006, [0018] (“A

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

140. Frank’s system is illustrated in Figure 1, reproduced below. As shown in Figure 1, the system includes an amplitude estimator. As I explain below, in the combined system, Zha’s teachings would be applied to Frank to provide a joint amplitude estimator as described in the ’651 claims.



141. Accordingly, Frank in combination with Zha renders obvious this element.

(b) [1a]: “a data stream from said multiple users divided into a plurality of observation intervals;”

142. In my opinion, Frank in combination with Zha renders obvious this element.

143. With respect to the element **“a data stream from said multiple users”**, Frank discloses receivers in a CDMA communication system that has “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”), [0019] (describing how a received signal is despread “for all users or all logical channels in use”), [0028] (describing how the system “is implemented to “despread all symbols from all users”). The communication channel with multiple users is at least part of the data stream.

144. With respect to the element **“divided into a plurality of observation intervals”**, Frank discloses the received signal in the data stream is “correlated with ... orthogonal (Walsh) codes or, equivalently, with any other set of channelization codes” to “despread all symbols from all users.” Ex. 1006, [0028]. In my opinion, a POSITA would have understood that in a CDMA system such as Frank’s, each code corresponds to an observation interval. By correlating the received signal with the orthogonal (Walsh) codes, the data stream is divided into a plurality of observation intervals, each corresponding to one of the orthogonal codes. That is consistent with the ’651 patent, which teaches that observation intervals are “based on distinguishing attributes selected from at least one of the group consisting of: time, code, and frequency.” Ex. 1001, 10:16-18.

145. In addition, as I summarize above, and as I explain in more detail in Limitation [1c] below, when Frank is combined with Zha, Zha's amplitude averaging methods are applied to Frank's receiver. Zha's algorithm for amplitude averaging includes, for each user, "averaging the instantaneous estimate of [the user]'s amplitudes over a block of M bits after despreading." Ex. 1010, 744. The block of M bits represents a plurality of time intervals, each corresponding to one of the M bits. *Id.*, 743 (decomposing the received signal into of a sequence of values $A_k(i)$, corresponding to each user's "signal amplitude, phase shift and data bit for the i th time interval," and computing a "received signal corresponding to the m th observation interval"), 744 ("The received signal vectors r over the $(M + 1)$ observation intervals provides the sufficient statistics for detecting the transmitted data bits from all the K users.").

146. Accordingly, Frank in combination with Zha renders obvious this element.

- (c) **[1b]: "a plurality of processing modules coupled to said observation intervals, wherein said processing modules calculates interference cancellation values for each of said users and computes a filter for each of said observation intervals, said filter being applied to said data within said observation interval to compute individual amplitude estimates; and"**

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

148. With respect to the element **“a plurality of processing modules coupled to said observation intervals”**, Frank discloses that its CDMA receiver includes a “processor 310” that implements the “[v]arious functions of the present invention.” Ex. 1006, [0048]. The processor does not have to be a single processor, but can include multiple processing modules, such as “a plurality of integrated circuits or other components connected, arranged or grouped together, such as microprocessor, digital signal processors (‘DSPs’), custom ICs, application specific integrated circuits (‘ASICs’), field programmable gate arrays (‘FPGAs’), associated memory (such as RAM and ROM), and other ICs and components,” and thus “include[s] ... [an] arrangement of custom ICs, ASICs, processors, microprocessors, controllers, FPGAs, or some other grouping of integrated circuits which perform the functions discussed ... with reference to FIGS. 1-2.” *Id.*, [0049]. In my opinion, a POSITA would have thus understood that each of the processing modules described by Frank is coupled to an observation interval, such as a code corresponding to a user, or a time interval in the block of data in the proposed combination with Zha. At a minimum, it would have been obvious to use multiple processing modules to process the different codes and time intervals, because it was well known that parallel processing using multiple processors may be used to increase the speed and throughput of a system.

149. With respect to the element **“wherein said processing modules calculates interference cancellation values for each of said users”**, Frank discloses that the functions implemented using its processing modules perform interference cancellation, including parallel interference cancellation or successive interference cancellation. *See, e.g.*, Ex. 1006, [0018] (“FIG. 1 is a block diagram illustrating a preferred receiver **100** for MMSE equalization with parallel interference cancellation.”), [0025] (similar for Fig. 2), [0040] (“The receivers **100** and **200** may be implemented in a successive interference cancellation mode.”), [0049] (the processor “perform[s] the functions discussed above with reference to FIGS. **1-2**”). Interference cancellation is performed for each “code channel,” which corresponds to a user. Ex. 1006, [0040] (“This successive interference cancellation generally removes multiple access interference from code channels in the order of strongest to weakest.”).

150. In addition, as I explain in more detail below for Limitation [1c] below, when Frank is combined with Zha, Zha’s amplitude averaging methods would be applied to Frank’s receiver. Specifically, a POSITA would improve Frank’s receiver by using the averaged amplitude estimates for each user, as taught by Zha, to calculate interference cancellation values for each user. Zha describes how the averaged amplitude estimates (highlighted in yellow in the formula from Zha shown below) are used to iteratively compute “the k -th user’s received signal” by

“subtracting other users’ regenerated signals from the received signal $\mathbf{r}(i)$.” Ex. 1010, 744.

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

151. In the equation above, the estimated signal for user k in iteration $v + 1$ is calculated by summing the interference cancellation values for each other user. As illustrated above, this equation uses the averaged amplitude estimates (highlighted in yellow) taught by Zha.

152. With respect to the element **“wherein said processing modules ... computes a filter for each of said observation intervals, said filter being applied to said data within said observation interval to compute individual amplitude estimates”**, Frank discloses filtering the received signal using a “linear feedforward equalizer (‘LFE’).” Ex. 1006, [0018] (discussing the “filter coefficients” of the LFE); *see also id.*, [0019] (describing subsequent functional blocks as processing the “filtered signal”), [0021] (LFE 145 “is also preferably implemented as a MMSE equalizer or as a matched filter”). Frank also performs “correlation or filtering” for “all orthogonal (Walsh) codes available or in use” to “despread all symbols from all

users.” *Id.*, [0028]. The correlation/filtering process separate the input signal into an individual signal for each user, based on the code associated with that user. A POSITA would have understood that the resulting signals would each include an amplitude. *Id.*, [0029] (referring to “the amplitudes of the outputs of the correlators for these code channels”). As I explain above, a POSITA would have understood or found it obvious to perform this functionality on the multiple processing modules described in Frank. *Id.*, [0048]-[0049].

153. In addition, as I explain in more detail below for Limitation [1c], when Frank is combined with Zha, Zha’s amplitude averaging methods are applied to Frank’s receiver. As I explained above for Limitation [1a], Zha discloses dividing the received signal into a plurality of observation intervals corresponding to different time intervals, each associated with a bit in the block of M bits. Ex. 1010, 743-44. A POSITA would have understood that in the combined system, Frank’s filters would be separately computed and applied to each bit to calculate an individual amplitude estimate for that bit for a given user. Zha also discloses obtaining an “averaged amplitude estimate” by averaging “the instantaneous estimate of [a user]’s amplitudes,” *i.e.*, a user’s individual amplitude estimate, “over a block of M bits.” Ex. 1010, 744. Zha provides the following formula for the calculation of the averaged amplitude estimate for a user k :

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

154. In this equation, the term that is being summed (*i.e.*, the term to the right of the summation symbol, sigma) is the individual amplitude estimate for a single bit/time interval. This is clear because the sum is performed over the set of values from 1 to M , which is each of the bits in the block of M bits. Each individual amplitude estimate is computed by applying a filter for that user and that bit, $\mathbf{d}_k(i)$, which corresponds to the k th user's spreading codes and time delay. *Id.*, 744.

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

- (d) [1c]: “an amplitude estimation unit which processes said individual amplitude estimates and calculates new amplitude estimates, wherein said new amplitude estimates are iteratively passed back to said processing modules either a maximum number of iterations or a desired bit error rate have been reached.”

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

157. With respect to the element “**an amplitude estimation unit which processes said individual amplitude estimates and calculates new amplitude estimates**”, in my opinion, it would have been obvious to a POSITA to include an amplitude estimation unit in Frank's system in view of Zha.

158. Zha discloses a “SIC [successive interference cancellation] receiver with amplitude averaging” that “has multiple interference cancellation stages,

starting from stage $\nu = 1$.” Ex. 1010, 744. “During the $(\nu+1)$ st stage,” “the averaged amplitude estimate” is processed for each user “by averaging the instantaneous estimate of [the user’s] amplitudes over a block of M bits after despreading.” *Id.* The $(\nu + 1)$ st stage refers to an arbitrary stage $\nu + 1$, and thus includes every stage (which is equivalent to an iteration) after the first stage. The averaged amplitude estimate provides a new amplitude estimate for each user for that iteration. The averaged amplitude estimate is computed by summing together and averaging individual amplitude estimates for each user over a block of M bits. These aspects of Zha are all reflected in the equation below, which shows how Zha computes a new amplitude estimate for user k during an iteration $\nu + 1$:

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

159. This calculation is equivalent to how the ’651 patent calculates updated amplitude estimates. In the ’651 patent, the joint amplitude estimator “combines individual [amplitude] estimates, $\Delta_{\underline{a}_m}$ ” which are “the individual estimates ... for each [observation] interval 1- M .” Ex. 1001, 19:60-20:20. As shown above, Zha’s averaged amplitude estimates similarly process amplitudes for observation intervals corresponding to a bit in the block of M bits, by “averaging [*i.e.*, combining] the instantaneous estimate of” a given user’s individual “amplitudes over a block of M bits.” Ex. 1010, 744. This process is repeated at each stage (iteration) of the receiver

other than the first state (*i.e.*, all stages $v + 1$). Each time, Zha re-estimates the amplitudes based on the previous iteration of interference cancellation in order to produce new amplitude estimates. Ex. 1010, 744. This is reflected in the equation above in the term $\tilde{\mathbf{r}}_k^{v+1}$, which corresponds to user k 's estimated signal after interference cancellation in the most recent iteration. That value is used to calculate the individual amplitude estimate for each bit in the block of M bits, and those estimates are then summed together and averaged to generate the new amplitude estimate for that user, $\bar{A}_k^{v+1}$.

160. As I explain above in Section VII.B.1, in my opinion, a POSITA would have been motivated to combine Frank and Zha, and would have reasonably expected the combination to succeed.

161. With respect to the element **“wherein said new amplitude estimates are iteratively passed back to said processing modules”**, as I explained above for Limitation [1b], Frank discloses processing modules that calculate interference cancellation values for each user. The interference cancellation values are computed by “regenerating” an “estimated transmitted signal,” which is used “to remove multiple-access interference from the symbol estimates.” Ex. 1006, [0035]-[0036]. Zha also discloses performing interference cancellation by “subtracting other users’ regenerated signals from the received signal $r(i)$ ” for each bit i (associated with a

time interval) in the block of M bits. Ex. 1010, 744. As shown in the equation below from Zha, in each iteration, each user's estimated signal is computed by subtracting other users' regenerated signals, which are themselves computed using new amplitude estimates from the previous iteration. For example, when estimating user k 's signal, the signals for users $k+1$ to K are regenerated by performing, for each user, a summation of the user's signals across all M bits (*i.e.*, across all of the time intervals). This is reflected in the yellow highlighted portion of the equation from Zha, as shown below. *Id.*, 744. The calculation makes use of the averaged amplitude estimate, highlighted in orange.

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

162. As shown above, the new amplitude estimates must be passed back to be used in calculating the interference cancellation values in the subsequent iteration. Thus, in the combination of Frank and Zha, in order for Frank's interference cancellation to make use of Zha's averaged amplitude estimates, the estimates would be iteratively passed back to Frank's processing modules to calculate interference cancellation values in the subsequent iteration.

163. With respect to the element **“either a maximum number of iterations or a desired bit error rate have been reached”**, Frank teaches that interference cancellation is performed until “an iteration limit has been exceeded.” Ex. 1006, [0042]. An iteration limit is a maximum number of iterations—the number of iterations cannot exceed the limit. Zha similarly teaches that the interference cancellation process “terminate[s] after a desired number of cancellation stages.” Ex. 1010, 744. Accordingly, in the combined system, interference cancellation (including calculation of new amplitude estimates) would continue until a maximum number of iterations is reached.

164. Accordingly, Frank in combination with Zha renders obvious this element.

3. Claim 2: “The joint amplitude estimator 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.”

165. In my opinion, Frank in combination with Zha renders obvious this claim.

166. As I explained above for Limitation [1c], in the combination of Frank and Zha, interference cancellation continues until a fixed, maximum number of iterations is reached. Specifically, Frank discloses performing interference cancellation until “an iteration limit has been reached” (Ex. 1006, [0042]), and Zha

discloses iteratively calculating new amplitude estimates and interference cancellations for “a desired number of cancellation stages” (Ex. 1010, 744). A POSITA would have understood that both Frank and Zha are referring to a predetermined, fixed number of iterations.

167. Accordingly, Frank in combination with Zha renders obvious this element.

4. Claim 3: “The joint amplitude estimator according to claim 1, wherein said amplitude estimation unit sums and weighs said individual estimates.”

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

169. As I explained above for Limitation [1c], a POSITA would have been motivated to apply Zha’s teachings regarding averaged amplitude estimation to Frank’s system, and would have reasonably expected to be successful in doing so, for the reasons I provide in Section VII.B.1 above.

170. Zha uses the formula below to calculate an averaged amplitude estimation, $\bar{A}_k^{v+1}$, for each user k across M observation intervals. Ex. 1010, 744.

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

171. The formula performs a summation, reflected by the sigma term,

$$\sum_{i=1}^M$$

, of the individual amplitude estimates for each bit, 1 to M. As I explained previously, each bit is a time interval of the received signal. The individual amplitude estimates are represented by the equation inside the summation,

$$abs (Re (e^{-j\theta_k} (\mathbf{d}_k(i))^H \tilde{\mathbf{r}}_k^{v+1}))$$

. Within this term, $\tilde{\mathbf{r}}_k^{v+1}$ is the received user's signal; $\mathbf{d}_k(i)$ is a filter, as I discuss above, which filters based on the time delay associated with the given bit for the given user; and $e^{-j\theta_k}$ functions as a weight for each individual estimate.

172. Alternatively, even if the $e^{-j\theta_k}$ is not considered to be a weight for each individual amplitude estimate, a POSITA would nevertheless understand that, at a minimum, the individual amplitude estimates are weighted by virtue of the fact that they are averaged. In other words, each individual amplitude estimate

contributes at most $\frac{1}{M}$ of the value of the averaged amplitude estimate. Thus, Zha's averaged amplitude calculation sums and weighs individual amplitude estimates.

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

5. **Claim 4: “The joint amplitude estimator according to claim 1, wherein said observation intervals are based on distinguishing attributes selected from at least one of the group consisting of time, code, and frequency.”**

174. *See* Limitation [1a].

6. **Claim 6**

- (a) **[6pre]: “A method for processing amplitude estimates for a multiuser data stream divided into a plurality of observation intervals, comprising:”**

175. *See* Limitations [1pre], [1a].

- (b) **[6a]: “computing a filter for each said observation interval of said data stream”**

176. *See* Limitation [1b].

- (c) **[6b]: “applying interference cancellation to said data stream for each said observation interval”**

177. *See* Limitation [1b].

178. In addition, when Frank and Zha are combined, interference cancellation would be applied for each bit in the block of M bits (each bit corresponding to a time interval).

179. As I explained above, a POSITA would have been motivated to apply Zha’s teachings regarding averaged amplitude estimation to Frank’s system. Zha discloses that its averaged amplitude estimates are used to calculate interference cancellation values corresponding to “other users’ regenerated signals.” Ex. 1010,

744. Interference cancellation is then applied to “the received signal $r(i)$ ” by computing interference cancellation values for each bit in the block of M bits, for each other user. This is reflected by the summation terms in the equation below that sum from $i=1$ to M , which is , which is each bit in the block of M bits (in other words, each observation interval).

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

- (d) [6c]: “applying said filter to said data stream for each said observation interval from said interference cancellation to produce individual amplitude estimates for each said observation interval”

180. See Limitation [1b].

181. In addition, as shown in Figure 1 of Frank, a filter is applied to the data stream from interference cancellation. The filter disclosed in Frank (*i.e.*, LFE 145, in purple below) is applied to the data stream from the interference cancellation (*i.e.*, the received data stream after subtracting the estimated received signal at 135, in red below). Ex. 1006, Fig. 1.

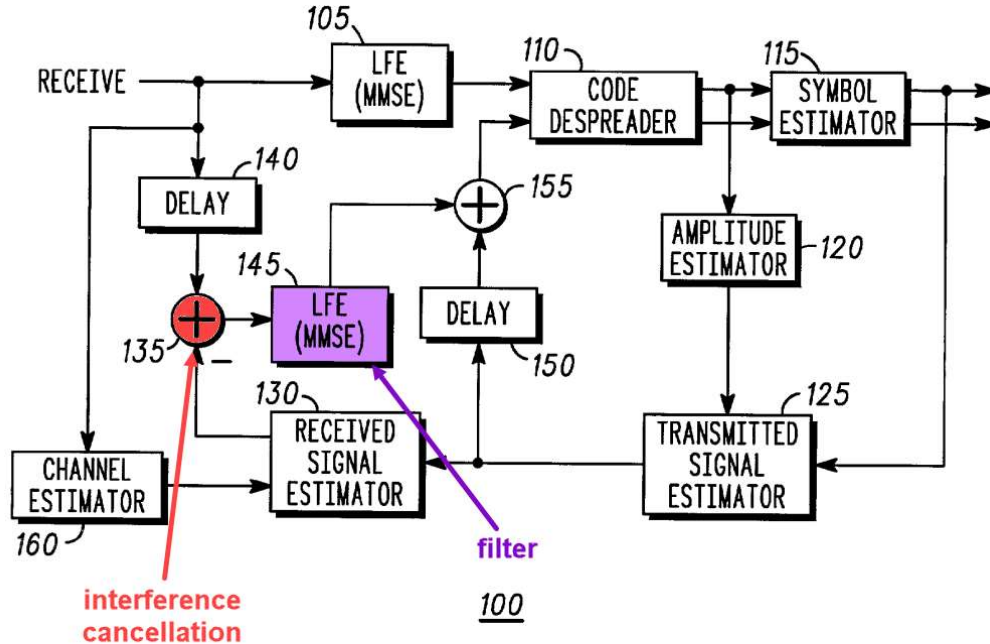


FIG. 1

182. As I discuss above, Zha also discloses a filter that is used to produce individual amplitude estimates. The filter is shown in the equation for the averaged amplitude estimates, and is highlighted in purple below. Ex. 1010, 744. As shown in the equation, the filter is applied to (multiplied by) the data stream from interference cancellation, which is the estimated user signal $\tilde{\mathbf{r}}_k^{v+1}$ (in red below).

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

183. Accordingly, Frank in combination with Zha renders obvious this limitation.

- (e) **[6d]: “computing new amplitude estimates using said individual amplitude estimates; and”**

184. *See* Limitation [1c].

- (f) **[6e]: “passing said new amplitude estimates back to said filter for iterative processing until either a maximum number of iterations or a desired bit error rate have been reached.”**

185. *See* Limitation [1c].

7. **Claim 7: “The method according to claim 6, wherein said computing further comprises summing said individual amplitude estimates and weighing.”**

See Claim 3.

8. **Claim 8: “The method according to claim 6, wherein said final condition is selected from at least from the group consisting of bit error rate metric level and fixed number of iterations.”**

See Claim 2.

VIII. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

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

187. Secondary considerations could include things like commercial success of a product due to the merits of the claimed invention; a long felt need for the solution provided by the claimed invention; unsuccessful attempts by others to find the solution provided by the claimed invention; copying of the claimed invention by others; unexpected and superior results from the claimed invention; acceptance by

others of the claimed invention as shown by praise from others in the field or from the licensing of the claimed invention; teaching away from the conventional wisdom in the art at the time of the invention; independent invention of the claimed invention by others before or at about the same time as the named inventor thought of it; and other evidence tending to show obviousness.

188. Patent Owner has not identified any such secondary considerations, and I am not independently aware of any. For example, Patent Owner has no commercial products embodying the '651 patent that I am aware of. Additionally, as discussed throughout, the claimed features reflect predictable results of combining known elements according to their known functions, and thus, there are no unexpected and superior results from the claimed invention. Also, there are no licenses of the '651 patent of which I am aware.

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

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

IX. CONCLUSION

191. For the reasons set forth above, I believe claims 1-4 and 6-8 of the '651 patent are unpatentable in view of the prior art. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in this case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

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

Dated: October 2, 2024

By: 
Paul S. Min, Ph.D.